GEOGRAPHY,
RESOURCES & INDUSTRIES

EDISON ELECTRIC INSTITUTE BULLETIN

SEPTEMBER, 1942

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EDISON ELECTRIC INSTITUTE

THE ELECTRIC LIGHT AND POWER INDUSTRY

Current Statistical Data Covering 100 Per Cent of Industry

JUNE AND JULY, 1942

	JUNE	JULY
	SOURCE AND DISPOSAL OF ENERGY	
Generation* (Net)		
By Fuel Burning Plants	9,826,167,000	10,875,755,000
By Water Power Plants	5,352,320,000	5,128,146,000
Total Generation	**15,178,487,000**	**16,003,901,000**
Add—Net Imports Over International Boundaries		
Less—Company Use		
Less—Energy Used by Producer	NOT YET	AVAILABLE
Net Energy for Distribution		
Losses and Unaccounted for		
Sales to Ultimate Customers	**12,669,868,000**	**13,165,930,000**
	CLASSIFICATION OF SALES	
Number of Customers		
Residential or Domestic	26,376,143	26,439,594
Rural (Distinct Rural Rates)	1,097,666	1,094,426
Commercial or Industrial:		
Small Light and Power	4,297,159	4,287,708
Large Light and Power	148,930	148,973
Other Customers	121,241	119,793
Total Ultimate Customers	**32,041,139** (a)	**32,090,494** (a)
Kilowatthour Sales		
Residential or Domestic	2,025,125,000	2,053,351,000
Rural (Distinct Rural Rates)	270,229,000	334,694,000
Commercial or Industrial:		
Small Light and Power	2,160,341,000	2,246,681,000
Large Light and Power	7,205,486,000	7,481,765,000
Street and Highway Lighting	131,668,000	137,187,000
Other Public Authorities	302,280,000	321,534,000
Railways and Railroads:		
Street and Interurban Railways	324,886,000	329,297,000
Electrified Steam Railroads	183,626,000	192,428,000
Interdepartmental	66,227,000	68,993,000
Total to Ultimate Customers	**12,669,868,000**	**13,165,930,000**
Revenue from Ultimate Customers	**$227,056,600**	**$232,460,300**
	RESIDENTIAL OR DOMESTIC SERVICE (Revised Series)	
Average Customer Data—For the 12 Months Ended	**(June 30th)**	**(July 31st)**
Kilowatthours per Customer	1,009	1,011
Average Annual Bill	$37.23	$37.31
Revenue per Kilowatthour	3.69¢	3.69¢

* By Courtesy of the Federal Power Commission.

(a) Subject to Revision following state by state analysis now under way.

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EDISON ELECTRIC INSTITUTE BULLETIN

Volume 10 SEPTEMBER, 1942 No. 9

"I made up my mind that the problem of the subdivision of the electric current could be solved and made commercial."—Thomas A. Edison.

Entering the Seventh Decade of Electric Power

Some Highlights in the History of Electrical Development

By Charles E. Neil
The North American Company

ON September 4, 1942, the electric light and power industry reached its sixtieth birthday. It now enters upon its seventh decade, one which may prove to be its most important, for a burden is upon it as great as any it has ever faced.

In the early years of the industry, it was a lighting business. At the turn of the century it began to make strides in the supplying of factories with electric motor power. Today its service in lighting the nation is without a counterpart anywhere in the world, but electric power is the emergency all-important factor—power which is being used in huge quantities to forge and process the machines of war.

Tremendous advances have been made in the development and supplying of factory motor power since World War I. In 1914, at the beginning of that conflict, the factories of this country had 3,885,000 horsepower of motors driven by purchased electric energy. At the beginning of World War II, in 1939, the motors on purchased energy had increased to 29,888,000 horsepower—an increase of 670 per cent in the 25 years! Factories in 1914 also had 18,406,000 horsepower of prime movers of their own, to run machinery and motors. In the 25 years to 1939 this figure had increased to 21,236,000 horsepower—or an increase of 15 per cent.

While the proportion of prime movers within the factories dropped from 82.57 per cent in 1914 to 41.54 per cent in 1919, the proportion of electric motors driven by central station energy increased from 17.43 per cent to 58.46 per cent.

The average factory worker in 1914 had an aggregate of 3.20 horsepower at his command, of which 0.56 horsepower was in motors driven by purchased energy. Today each worker has an average of 6.50 horsepower to use, of which 3.80 horsepower is motor power run on purchased energy. The average per-worker purchased energy horsepower is greater today than the total factory horsepower per worker in 1914.

Dr. Karl Compton, in referring to the mechanization of the United States has stated that the engineering advances have made available here 6 billion man-power—"equivalent to 50 slaves for each man, woman and child."

Growth of the Electric Industry

The electric light and power industry has been continuously "among the fastest growing of all forms of enterprise," the Brookings Institution has noted. Measured by production of its energy it truly has demonstrated a remarkable growth, not only from its earliest days up to 1929, but the increase since that year has been extraordinary.

It is extremely doubtful if any industry can show a record of year-to-year *continuous* growth equal to that of the electric light and power industry. The long-time trend clearly shows that the growth by decades has been ever upward. While complete industry figures of electric production do not exist for the early decades, there are available the annual growth figures of some of the central stations from their beginnings in the '80s and '90s. In each of the individual central station statistical growth trends that have been observed, not one showed a decline in any year of the first three or four decades—not even in the depression years, such as 1893 and 1907-8. The original Edison central station and its successor system in New York City recorded a gain in load or production in every year from 1882 to the year 1932, which was the first and only year to show a temporary decline in kilowatt-hour output!

It was not until 1921 that power production for the whole country, as measured by kilowatt-hours, showed a temporary drop. Based on the records of a number of companies, it is probable that this was the first year from 1882 to show a decrease in output. The trend of annual increase in production was resumed the next year, 1922, and has continued except for the 1930-1932 period of the recent depression. Since

TABLE I

Year	*Population Millions*	*Electric Production in Billion Kilowatt-hours*	*Kilowatt-hours per capita*	*Per Cent Increase in Per capita*
1902	79.4	4.8	60	...
1907	87.5	10.6	121	102%
1912	95.1	17.9	188	55
1917	102.2	33.2	325	73
1922	109.9	43.3	394	21
1927	118.2	74.0	626	59
1932	124.6	78.0	626	0
1937	129.0	115.7	897	43
1942	132.6	188.0 (Est.)	1,417	58

then the growth has been rapid. The 1942 output exceeding that of 1929 by 96 per cent, having gone from 96 billion kwhr in 1929 to an estimated 188 million kwhr in 1942.

The production of energy in kilowatthours in the United States from the year of the first official census of the electric industry, 1902, to the present year, is given in Table I. The figures include the total output of energy for public use, including energy generated by electric railways, government plants, etc. Production is also shown on a per capita basis.

Early Electric Systems—Service Areas—Competition

Many lighting "systems" preceded the Edison central station system, and many came after its creation. In Great Britain the first lighting system was registered May 31, 1875, under Gramme patents. In 1878 the British Electric Light Company was formed, as sole licensee for the Gramme machines. The record of the early registered companies shows that most of them "wound up" and died; or "nothing paid up"; or "showed a loss." For example, the Brush Electric Light and Power Company of Scotland, registered in 1882, to handle Brush-Lane-Fox patents, "wound up voluntarily" in October 1883. Among the various "systems" were included: Gramme, C. F. Brush, Jablochkoff, Siemens, Swan, Weston-Maxim, Laing, Pilsen, Faure, Fyfe, Gulcher, Chartemps, Joel, Gatehouse, Fitzgerald, Duplex, Sun, etc.

In this country at the same time there were fifty or more separate lighting "systems," mostly for arc lighting. Today only one system survives—the Edison system, all the other systems having "wound up" many years ago as observed by T. C. Martin, "For such a complete disappearance as that it is hard to find a parallel in the arts and mechanics." Two of the more important early lighting systems which made valuable contributions to electrical development were the Brush and Thompson-Houston systems. The manufacturing plant of the latter became the nucleus of the present General Electric Company.

The Brush System

Following the first public demonstration of the Brush arc lamp at Monumental Park, Cleveland, on April 29, 1879, the inventor and organizer Charles F. Brush initiated his first arc lighting central station as a commercial venture in San Francisco. The California Electric Light Company was organized June 30, 1879, to operate the system and actual service began in September, 1879, from the plant which was located at Fourth and Market Streets. The Brush Electric Light & Power Company of New York was organized September 24, 1880. and built a generating station at 133 West 25th Street. Arc service began December 20, 1880, with lights on Broadway from 14th to 25th Streets, and was later extended to 34th Street. By 1881 there were Brush arc stations in Cleveland, Albany, Baltimore, Philadelphia, Boston, Cincinnati, Buffalo, Rochester and other cities.

The T-H System

The Lynn Electric Lighting Company of Lynn, Mass., was the first to use the Thomson-Houston system. The company was formed in 1882 and by 1883 had 90 arc lights in use. Many local companies purchased their arc equipment from the Thomson-Houston Company, and by the end of 1883 Kansas City had installed 210 arc lights of this type. Other T-H installations were: Boston, 200; Hartford, 100; Portland, Me., 75; Quincy, Ill., 45; Des Moines, Iowa, 25; etc.

The Edison System

The breadth of conception of Edison in planning in advance for every branch of the electric central station is one of the most remarkable aspects of the development of the electrical industry. When he first started to work on the problem he could see in his mind the many things he would have to invent and develop on a commercial scale to make such a central station successful.

Edison began by studying every angle of the gas business, with the objective of effecting "exact imitation of all done by gas, so as to replace lighting by gas, by lighting by electricity. . . . It doesn't matter if electricity is used for lighting or for power. Small motors can be used day and night. . . . Generally poorest district for light, best for power, thus evening up the whole city—note the effect of this on investment."

A complete system of electric distribution had to be evolved. Means had to be found to maintain even voltage. Dynamos had to be built more efficient and larger than any then made. ". . . I made up my mind," he wrote, "that I wanted to sell all the electricity I made and not waste half in the machine, so I made my internal resistance small and got 90 per cent of salable electricity." He had to invent and perfect many other devices—to prevent excessive currents—proper switching gear, lamp holders, etc.

The first commercial installation of the Edison incandescent lamp and dynamo system was that made on the steamship "Columbia," which was owned by the Oregon Railroad & Navigation Company, and started on its trip around Cape Horn to San Francisco on May 2, 1880. The famous Pearl Street Station, the first central generating plant and its component distribution system, began operation in New York sixty years ago on September 4, 1882.*

On July 4, 1883, in Sunbury, Pa., the Edison Electric Illuminating Company of that city, first began electric incandescent service with the famous Edison three-wire system, which saved 62½ per cent in the cost of copper conductors. Its successful operation here made it universally adopted in all other Edison stations thereafter. The line in Sunbury was overhead, but shortly thereafter a three-wire system was installed in Brockton, Mass., with underground distribution.

Service Area of Early Edison Plants

The Pearl Street plant in New York served an area about a mile square, the northern-most point reached being Park Row. For some years after the service area of electric plants was limited, and supplied only the central parts of the cities.

In 1904, the late Alex Dow gave some figures of area limits of Edison central stations in the large cities, in which the greater part of the lighting business of the country was then centered. The following table shows some of the cities as to area served by Edison distribution systems:

	In Square Miles	
	Total Area	*Area Served*
New York (Manhattan)	22	15½
Chicago	190	12
Philadelphia	130	3
St. Louis	63	7½
Boston	43	4
Cleveland	33	1¼
Detroit	29	3
Buffalo	51	5

It was shortly after this time that the rapid spread of service to the residential

* The N.E.L.A. Bulletin for September, 1922, carries an extensive account of this station by the author.

districts began, until service became available in all parts of both large and small cities.

In the first decades of the electric industry electricity in the home was a luxury and it appeared in few homes for this reason. Complete service was sold by the central stations, and the cost of wiring existing homes, installing chandeliers, lamps, meters, etc., together with the cost of the current came to quite a sum. The first houses to be lighted by electricity were those of E. H. Johnson in Greenwich, Conn., and Senator D. M. Sabin, in Stillwater, Minn., in the early '80s. The first homes to be lighted by an incandescent central station were those of H. J. Rogers, and H. D. Smith and A. L. Smith in Appleton, Wisconsin, in September, 1882. In 1883, in Roselle, N. J., the Edison lamps were placed in some 50 dwellings.

Competition in Various Forms

The Edison incandescent lighting central station was planned as a competitor of the gas lighting business and the electric arc lighting business. The first charges made for incandescent lighting were based on contemporaneous equivalent gas rates. The electric railways were a product of the 1880s and they also became a competitor in the lighting business to a limited extent—by selling a portion of their electric energy for lighting purposes.

The gas industry was 66 years old when Edison developed his electric central station in 1882. Some of the gas companies saw operating advantages and economies possible in the combination of electric and gas systems, which prompted them to install electric systems. In 1907 there were 329 out of the 4,714 electric central stations which were associated with gas enterprises.

Not only central stations, both arc and incandescent, began to spread over the country, but in addition thousands of smaller "isolated plants" were installed by individual customers, including many Edison isolated plants. In 1902 when there were some 3,600 electric central stations there were also about 50,000 isolated plants in the United States, having facilities about equal to the capacity of the central stations. In Greater New York in 1899 there were 1,250,000 16-cp lamp equivalent capacity in the central stations and 800,000 in the isolated plants. In Chicago the capacity of the isolated plants at that time exceeded that of the central stations.

The arc and the incandescent branches of electric lighting grew up quite independently for several years after their inception. There was intense commercial rivalry between companies of the two types. However, some arc companies soon began to operate also with incandescent lamps and by 1897 many of the stations were selling both arc and incandescent lighting.

In New York state the proportion of revenues derived from lighting and other services changed from 1890 to 1907 as shown in the following table:

Percent of Income—New York State

	1890	*1902*	*1907*
Arc lighting	54.43%	29.34%	....
Incandescent lighting	38.00	47.32	....
Total Lighting	92.43	76.66	69.80%
Stationary motors	4.62	14.22	16.30
Other service	2.95	9.12	13.90
Total	100.00	100.00	100.00

The census of 1902 shows a more detailed report on the class of service rendered by the central stations than in the partial report of 1897, and that only one-third of the companies were supplying current for motor service in 1902. The percentage of the 2,805 private stations and the 815 municipal stations rendering each class of service was as follows:

	Private Stations	*Municipal Stations*
Arc lighting:		
Commercial	59.5	43.3
Public	64.5	87.1
Incandescent lighting:		
Commercial	98.0	89.7
Public	67.5	73.7
Motor power:		
Stationary	34.8	14.5
Electric railway	5.6	0.2
Other services	5.4	1.1

Water Power Development—Factory Installations—1822-1880

The first great water power development in the United States was made on the Merrimack River in 1822 near Lowell, Mass., followed by similiar developments on the same river at Manchester, N. H., and Lawrence, Mass.

The beginning of water power development at Niagara Falls was in 1861, when a canal was constructed and in subsequent years water was delivered to many factories. In 1881 a central powerhouse was built, and the energy therefrom transmitted to several factories by means of belts, ropes and shafts.

By 1880 there was an aggregate of 1,250,000 hp of water power in the United States, the factories served all being located at the site of the water power.

First Hydro-Electric Central Station—1882

On September 30, 1882, the world's first water-driven electric central station was placed in successful operation at Appleton, Wis. Two paper mills and a residence were the first customers of this station, but within a few months several additional mills, a hotel and many residence customers had signed up for electric service. The original water wheel measured about 42 inches in diameter, operated under a ten-foot head and at a speed of 72 rpm. Two Edison "K" dynamos were used, each dynamo being capable of lighting 250 sixteen cp lamps, equivalent to a rating of about 12½ kilowatts. There were no voltage regulators, and the operators depended upon their own eyes to gauge the proper brightness for the lamps. There was no fuse protection. There were no meters, and customers were charged on a lamp basis per month, regardless of the hours of use. Service was from dusk to dawn. Distribution lines were of bare copper wire. The original customers paid about 33 cents per lamp per month. Labor for installing fixtures was 25 cents per hour.

As with most of the infant organizations financial worries continually faced the company's operations. Even with high prices, high rates and low labor costs the utility found hard sledding.

The company's 1894 annual report showed that the company, after 12 years of operation, owed some $96,000. The treasurer's report explained some of the difficulties as follows:

"Our income has been reduced very considerably in wiring because we could not afford to buy the material and because of the establishment of a new firm competing with us and cutting rates regardless of profits. The new lighting company also offered to wire all customers for nothing.

"The disasters of the past year have been the commencement of a suit against the company for $28,000 of our notes. By reason of this suit in which there was an attempt to put us into the hands of a receiver, we lost our credit. Under such circumstances I was obliged to default the interest on our bonds and a majority of our stockholders have commenced proceedings of foreclosure."

Still, the spirit of initiative and progress was not lacking in this first commercial hydro-electric company, for the treasurer ended his report with these words of optimism:

"To be effective and to meet competition we must build a new and modern station and increase our water power capacity which will cost about $24,000, for the load during the winter has been greater than our capacity."

The Keokuk dam and power plant in 1913 brought new designs in water wheels and turbines, the forerunner of

all modern low head vertical units. The multiple runner units at that time had efficiencies of between 70 and 80 per cent. The Keokuk single runner direct-connected vertical turbines had efficiencies of 90 per cent, and an entirely new type of governor was developed.

Alternating Current Displaces Direct Current

The rapid acceptance of alternating current contrasted with direct current caused considerable concern in the early '90s to the owners of the latter type of equipment. In 1895 one of the most important topics of discussion in electrical circles was the rapid perfection of the induction motor to the point where it could not be neglected by the central station operator. It was then pointed out that if the claims made on behalf of these motors should be maintained, "continuous (direct) current will be definitely placed in such a serious state of inferiority as to give real cause for alarm to its adherents, and should tend to make them consider the advisability of taking advantage themselves of the new advance rather than to wait for it to be exploited by a rival."

It was another one of the oft-occurring evolutions in the electrical art which presented serious problems to the central stations. At that time it was stated that even between annual meetings of the electrical fraternity the intervals "often witnessed a revolution in the art or its methods."

The record shows, however, that most of the central stations adopted alternating current, and the advance in this form proceeded rapidly, while direct current declined in general use. In the early '90s direct current accounted for 90% of central station capacity, and by 1897 only about 62%. By 1902 the percentage of direct-current capacity had dropped to 39%; in 1907 to 18%, and today less than 1% exists in the electric industry—this small amount being used mainly for railway service.

First Alternating Current—1886

In the first alternating-current plant in America, engineered and built by William Stanley at Great Barrington, Mass., in 1886, it was demonstrated how electric power could be generated at a low voltage, transformed into a higher voltage, transmitted at the higher voltage, retransformed to a lower voltage, and used at this voltage as might be required. Without this means of adapting voltage to varying requirements, and of maintaining it substantially constant, irrespective of the load, the enormous development and progress in the transmission and distribution of electric energy could not have taken place. Stanley at the age of 30 had conceived his idea of the manufacture of electric power in some suitable location, and transmitting and distributing it to points of consumption by the use of alternating current. He was determined to find out whether there were any voltage limitations in sight and, in 1892 when 2,000 volts was the highest line potential, he designed in Pittsfield, Mass., transformers and a line of 15,000 volts. He connected his line to the 15,000-volt line, sent the higher voltage current around a farm and back to the same transformer house, then retransformed the line potential to 1,000 volts, and operated the distribution transformers of the local company.

THE COMMERCIAL BIRTH OF THE PUBLIC UTILITIES
Some Historical Dates

	Year	
		Water Supply
Jan. 27,	1801	Philadelphia Water Works.
		Gas Supply
Apr.	1812	London & Westminster Gas Light & Coke Co.
Feb. 17,	1817	Gas Light Co. of Baltimore.
	1865	Natural gas—Fredonia (N. Y.) Gas Light & Water Works Co.
		Steam Railroads
Sep. 26,	1825	Stockton & Darlington Ry. (Stephenson, England).
May 22,	1830	Baltimore & Ohio R. R. — Ellicott's Mill.
May 10,	1869	Transcontinental — Union Pacific — Central Pacific.
		Telegraph
May 24,	1844	Morse — Baltimore to Washington.
May 15,	1845	Magnetic Telegraph Co. New York to Philadelphia.
	1846	Electric Telegraph Co. (England).
		Telephone
Mar. 10,	1876	Bell — 109 Court St., Boston.
Apr. 4,	1877	Boston to Somerville.
May	1877	Bell Telephone Association (Unincorporated).
Jan. 25,	1915	Transcontinental line.
		Electric Supply
		Arc Light
Jan.	1879	Brush dynamo — First one shipped to Dr. Longworth, Cincinnati, 4000 cp.
Apr. 29,	1879	First public street lighting, Public Square, Cleveland, Ohio, 12 lamps, 2000 cp.
Sep.	1879	First Arc Central Station, California Electric Light Co., San Francisco, Calif., (Two Brush dynamos, 22 2000 cp. arc lamps—Rate $10 per week per 2000 cp. arc lamp midnight schedule).
		Incandescent Light
Oct. 29,	1879	First Edison carbon lamps, Menlo Park, N. J.
Sep. 4,	1882	First Edison steam central station—Edison Electric Illuminating Co. of N. Y., 257 Pearl St., N. Y.
Sep. 30,	1882	First Edison hydro central station—Appleton (Wis.) Electric Company.
	1905	Gem lamp (Willis Whitney).
	1906	Tantalum lamp (Werner von Bolton).
	1907	Tungsten lamp (Alexander Just and Franz Hanaman).
	1913	Gas-filled Tungsten lamp (Irving Langmuir).
	1938	Fluorescent lamp.
		Electric Power Transmission
	1886	Electric transformer (William Stanley).
	1889	First—Willamette Falls to Portland, Ore., 4000 volts—13 miles.
	1892	Polyphase—step-up 2400 to 11,000 volts—Mill Creek to Riverside, Calif., 22 miles.
		Electric Railway
Jul. 31,	1884	Cleveland. (Bentley & Knight. Slot conduit.)
May 4,	1888	Richmond, Va. (Sprague. Trolley.)
Jan. 1,	1898	Interurban—Anderson to Alexandria, Ind. (Henry.)
		The First Utility Regulating Commissions
		Railroad
June	1839	Rhode Island
Dec.	1844	New Hampshire
Feb. 4,	1887	Interstate Commerce Commission
		Electric Light and Gas
Jun. 11,	1885	Massachusetts
		Modern Public Service Commissions
Jun. 6,	1907	New York
Jul. 9,	1907	Wisconsin
		Water Power
Jun. 10,	1920	Federal Power Commission

Power Plant Developments

In the early '80s the average size of the arc lighting system dynamo was about 10 kilowatts, and a 50-kilowatt dynamo was considered large. The efficiency of these dynamos was about 40 per cent. The relatively large capacity of Edison's 120-kilowatt, 90 per cent efficient dynamo, earned the name of "Jumbo." Even well into the '90s the average central station consisted of a single high-speed engine of 50 to 150 horsepower, with an arc dynamo of 25 light capacity, and an incandescent dynamo of 500 light capacity.

Table II shows the progress in the increased size of dynamos and generators in steam stations, and also the growth in size of the largest central stations, from 1882 to present times. Figs. 1 and 2 graphically illustrate the increases in size of both steam and hydraulic generators. From the original Edison "Jumbo" dynamo of 120 kilowatts to the 208,000 kilowatt generator in today's State Line plant near Chicago, is a long way; it would take 1733 Jumbos to equal the capacity of the State Line plant generator. A generator of 208,000 kilowatts does the work of 12 million men, working 8 hours each.

Even in 1888 when the Edison Electric Illuminating Company of New York erected its second generating station, on West 26th Street, and its third on West 39th Street, the steam engine units had reached a maximum of only 200 horsepower. When the Duane Street equipment was installed in May, 1891, engines were of 2500 horsepower, each with a pair of 800-kw dynamos.

TABLE II—GROWTH OF REPRESENTATIVE ELECTRIC GENERATOR SIZES AND STEAM POWER PLANTS 1879-1942

	Maximum Generator Size Kilowatts	*Plant Capacity Kilowatts*	*Plant*
	Reciprocating Engines		
1879	20	.....	Typical arc dynamo, 40% efficient
1882	120	720	Pearl Street, New York. Edison's "Jumbo" dynamos, 90% efficient
1888	200	3,200	Adams Street, Chicago
1889	250	3,276	Sansom Street, Philadelphia
1890	1,250	4,850	Albany Street, Boston
1893	1,600	7,600	Duane Street, New York
1897	2,000	3,100	Bay Ridge, Brooklyn
1898	2,750	30,250	96th Street, New York
1899	3,500	56,000	Waterside, New York
1901	5,000	45,500	74th Street, IRT, New York
1903	12,000	120,000	Fisk Street, Chicago
	Turbines		
1904	5,000	.....	Fisk Street, Chicago
1905	9,000	.....	
1906	12,500	.....	
1912	20,000	40,000	Northwest, Chicago
1915	45,000	180,000	Conners Creek, Detroit
1924	50,000	150,000	Trenton Channel, Detroit
1925	60,000	160,000	Crawford Avenue, Chicago
1928	94,000	94,000	Long Beach No. 3, California
1929	165,000	610,000	Hell Gate, New York
1929	208,000	208,000	State Line, Indiana

Improvement in Steam Production Efficiencies

The Pearl Street plant of 1882 was able to generate a kilowatt-hour—a term not then in use in this country—from the burning of about 10 pounds of coal. This represented a remarkable improvement over the average thermal efficiency of the engines then producing current for arc lighting. There are records of some

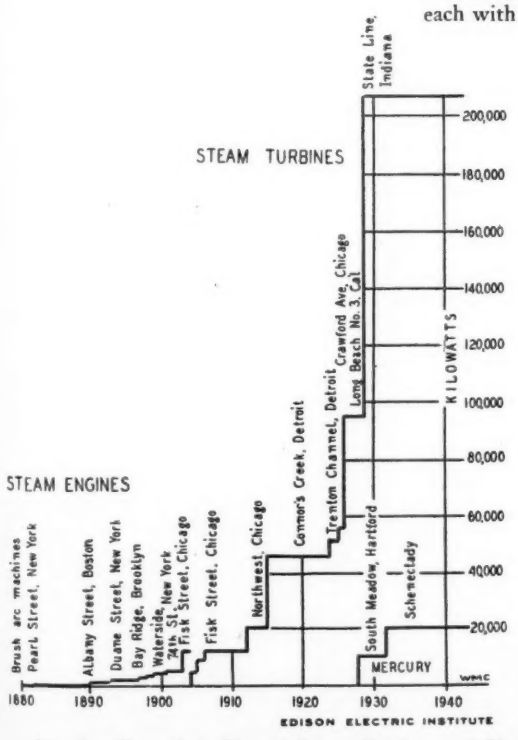

Fig. 1—Growth in Size of Steam Engines and Turbines

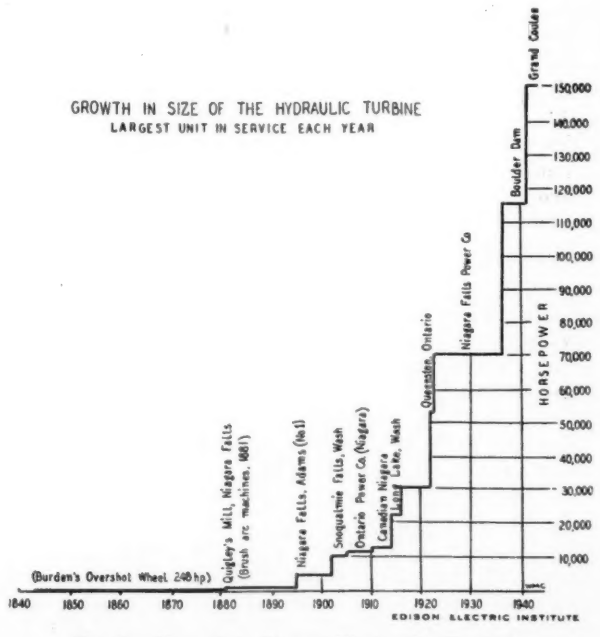

Fig. 2—Growth in Size of Hydraulic Turbines

small plants of the 1880s and 1890s using as high as 30 pounds of coal per kilowatt-hour.

The amount of coal required per unit of energy varied materially with the percentage of load on the early dynamos. In a study made in 1895 such a relationship was shown for a number of central stations of different sizes. The lesson learned from the investigation was the necessity for so proportioning the generating units of a station as to admit of each unit being worked at as nearly full load as possible.

In Table III are shown, in condensed form, the approximate amounts of coal burned per kilowatt-hour at selected loads on the dynamos for the larger efficient dynamos, medium size and the smallest and most inefficient.

It was apparent in the electric census of 1917 that the smallest group of steam power plants were still requiring as much as 18.26 pounds of coal per kwhr compared with 2.49 pounds for the largest group.

Table IV shows a series of figures giving the thermal efficiency of (a) prime movers from the time of the Newcomen engine (1770) to the mercury vapor turbine (1930); (b) of efficiency records of selected best-performance electric power stations, at intervals in which substantial improvements were achieved; and (c) the average thermal efficiency of all electric power plants in the country from 1882 to 1941. Most of these early records are from the compilations published from time to time by George Orrok. This trend is shown graphically in Fig. 3.

From the 10 pounds of coal used in 1882 to 0.75 pound in the best stations of today is truly a remarkable achievement—but observation of the long-time trend shows that the improvements have been gradual, and each decade has recorded a material gain in efficiency.

Pulverized Coal

In the fall of 1918 there began in the Oneida Street plant in Milwaukee experiments in the burning of powdered coal, under a 468 hp. boiler that had already seen 22 years of service. The Bureau of Mines cooperated in the work. Engineers predicted failure and questions were even raised as to the reliability of the published experimental results. However, the company decided to venture on a new power plant using only powdered coal, and thus the Lakeside Plant in Milwaukee, which began operation in 1920, was the first such plant in the world. The increase in steam production efficiencies completely justified the new method, and the succeeding years saw most of the new power plants throughout the country installing pulverized coal equipment.

The trend to pulverized coal increased to such an extent that of new boiler equipment installed in the five years 1936 to 1941 in central station plants, 90% of the steam generated is from powdered coal and 10% from stoker fired boilers.

Table III

Year 1895

Type of Engine	*Coal Burned Per Kilowatt-Hour Percent Load on Dynamo 100% Pounds*	*50% Pounds*	*20% Pounds*
Compound condensing engine, 2000 hp.	2.0	3.2	6.0
Compound non-condensing engine 300-800 hp.	4.5	7.0	14.0
Simple non-condensing engine 100-200 hp.	8.0	14.0	30.0

Mercury Vapor Turbines

At a meeting of power engineers in December, 1941, mercury as a thermal medium for power generation was declared to have "come of age," after 28 years of persistent experimentation. In 1928 the first mercury turbine, of 10,000 kw capacity, was installed in the South Meadow Station at Hartford, Conn. Four years later a 20,000-kw mercury turbine was built at Schenectady by the General Electric Co. A third was in-

Table IV—Gain in Thermal Efficiency in Steam Engines and Power Plants

Efficiency of Prime Movers

Year	*Prime Mover*	*Pounds Pressure*	*Equivalent Btu. per Kwhr.*	*Percent Thermal Efficiency**
1770	Newcomen engine	15	416,000	0.82
1900	Nordberg engine	215	19,200	17.75
1922	Turbine	265	18,000	19.00
1930	Mercury vapor turbine—Hartford, Conn.	140	10,300	33.10
1935	Port Washington power plant	1,245	10,850	31.50
1941	Mercury vapor turbine—Kearny, N. J.	350	9,175	37.30

Efficiency Records of Some Best Performance Electric Power Steam Plants

Year	*Btu. per Kwhr.*	*Percent Thermal Efficiency**	*Equivalent Pounds of coal at 13,800 Btu. per pound*	*Plant and Location*
1882	138,000	2.48	10.00	Pearl Street. New York City
1902	41,250	8.28	3.00	Waterside No. 1. New York City
1907	36,800	9.28	2.66	Waterside No. 2. New York City
1912	33,200	10.29	2.40	Lake Shore. Cleveland, Ohio
1917	20,040	17.05	1.45	Conners Creek. Detroit, Mich.
1922	18,674	18.29	1.35	Lakeside. Milwaukee, Wisconsin.**
1925	14,250	23.97	1.03	Philo. Ohio
1928	12,500	27.30	.91	Columbia. Cincinnati, Ohio
1934	11,900	28.71	.86	Gilbert. New Jersey
1937	10,669	32.02	.77	Port Washington. Wisconsin

Average Thermal Efficiency of all Electric Power Plants in United States

Year	*Btu. per Kwhr. U. S. Average All plants*	*Percent Thermal Efficiency**	*Equivalent Pounds of coal at 13,800 Btu. per pound*
1882	138,000	2.48	10.00
1887	125,000	2.74	9.05
1892	108,000	3.17	7.75
1897	96,000	3.56	6.95
1902	92,500	3.70	6.70
1907	74,500	4.59	5.40
1912	60,600	5.64	4.40
1917	45,500	7.50	3.30
1922	34,500	9.90	2.50
1927	25,400	13.45	1.84
1932	20,700	16.50	1.50
1937	19,700	17.35	1.43
1941	18,600	18.40	1.35

* 3,412 BTU, equal one kilowatt-hour.
** First pulverized coal plant.

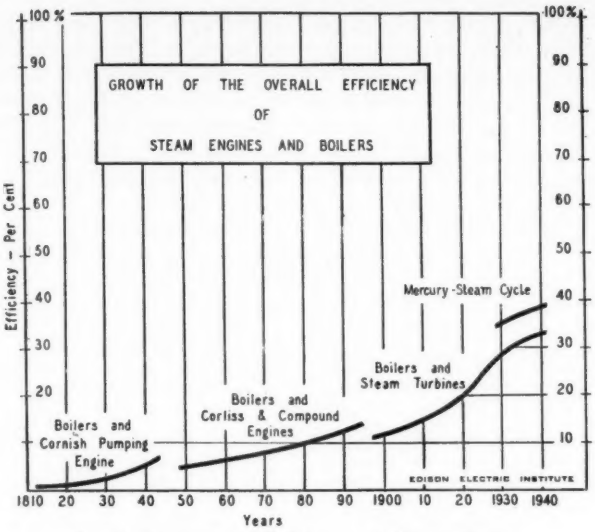

Fig. 3—Growth in Efficiency of Steam Power

stalled in the Kearny Station of the Public Service Electric & Gas Co. in 1940. This unit has shown a heat rate of 9,175 Btu. per kwhr in its operations of 1941-1942. H. N. Hackett, of the General Electric Co. has stated that future applications may attain better than 50 per cent thermal efficiency.

The Shift to Large Plants—Costs and Revenues per Kwhr Decrease

The electric industry recognized early the economic and operating advantages of large generating plants serving considerable territory over numerous small separated plants. By the first decade of this century the gradual change to unified and concentrated electric power generation from large capacity plants had begun, with consequent scrapping of the many small unefficient generating plants.

The 1917 electric census of the U. S. Bureau of the Census demonstrated the great progress that has been made in this direction by that year. Average costs and revenues per kilowatt-hour of some 5,124 central stations were given in a special section of the census, according to the size of the plant in current output. The series covered plants with outputs below 200,000 kwhr up to those producing 200 million kwhr and over, with separate data for steam, hydro, oil-burning and gas-burning plants. Not all of the larger plants were given, as the census could not disclose individual plant figures, but enough were given to show the full trend from small to large.

The largest plant group received from 1.63 to 2.50 cents per kilowatt-hour in revenue; the medium size plant group received from 3.50 to 5.50 cents per kwhr; and the smallest plant group received from 7.5 to 10.00 cents per kwhr, all of these figures being for steam generating plants. Revenues of the hydro plants were generally lower than those of the steam plants, but the range from large to small plants was practically in proportion to the steam plants. The oil generating plants ranged from 3.20 cents for the largest size group to 12.20 cents per kwhr for the smallest size group.

Developments in Electrical Transmission

The possibility of transmission of electricity was pointed out as early as 1850. It is claimed that in 1858 in the artillery works at St. Thomas d'Aquin, France, electricity for the first time was transmitted for driving a commercial machine.

Practical experiments by Gramme in 1873 are credited with being the first convincing demonstration of the possibility of employing electric current for transmitting energy from one place to another. His experiments consisted of transmitting current from a machine working as a generator to a second machine about 550 yards distant, working as a motor driving a pump.

In 1882, Marcel Deprez built the first long-distance transmission line from Miesbach to Munich, a distance of 37 miles. It was built purely for experimental and demonstration purposes, 2400-volt direct current being used. In 1886, Deprez completed a line from Criel to Paris, about 25 miles, transmitting 20 amperes direct current at a potential of 7500 volts. Transmission efficiency was about 32 per cent.

The first alternating current transmission system was constructed in Italy in 1886, and known as the "Cerchi Tivoli-Rome" plant. Equipment at the station consisted of two 150 hp steam-driven, single-phase Ganz generators designed to operate at 112 volts. Transformers having a ratio of 1:18 were used to step this voltage up to 2000, at which voltage energy was transmitted to Rome, a distance of 17 miles.

Early A-C Hydro-Electric Installations

In 1889 the first alternating-current hydro-electric installation was made at Oregon City, Ore., by the Willamette Falls Electric Company, power being transmitted 13 miles to Portland, Ore. The installation consisted of two 300-hp water wheels belted to single-phase generators. Capacity of the power house was 720 kilowatts, and the line was of 4000 volts.

In the winter of 1890 the San Miguel Consolidated Gold Mining Company installed on a fork of the San Miguel River near Ames, Colo., a power house of two 150-kilowatt single-phase Westinghouse generators, directly connected to Pelton water wheels, and transmitted the power at 3000 volts to the Gold King Mine, a distance of three miles. This mine was situated at an elevation of 12,000 feet, where the cost of fuel had been so prohibitive as to force the company into bankruptcy in 1888. L. L. Nunn, an attorney retained by the owners, found that there could have been a handsome profit if power could have been furnished at not more than $100 per horsepower-year!

Nunn felt electrically transmitted power would solve the cost problem, but he sensed the limitations of direct current and had faith in the ultimate success of alternating current. While selecting the electrical apparatus, he encountered little but incredulity and ridicule. Eastern investors in the enterprise were annoyed by predictions of prominent engineers, and discouraged by their insistence, that the experiment would prove a failure. In the construction and operation he ran into difficulties caused by ice at

40 degrees below zero; by speed control over unusually high water pressure (the equipment was a 6-foot Pelton wheel, operated at 320-foot head); by avalanche; by blizzard; by electric storms unknown at lower altitudes; and by many other troubles later generally forgotten.

Everything was extremely simple from waterwheels to motors and, except for lightning interruptions, the plant ran smoothly and steadily for 30 days without a stop. The announcement made in the East by associates of the enterprise that at Telluride, Colorado, electric power was being successfully transmitted nearly three miles over No. 3 copper wires with less than 5 per cent loss was received with incredulity.

Following its pioneer installation the company made practical experiments as early as 1895 with tests of pressures up to 60,000 volts, and in 1896 a 10,000-volt underground transmission line was put in operation at the Gold King Mine.

Despite the successful operation of these two early systems, an electrical engineer from California at the International Electrical Congress held in Chicago in 1893 made this statement:

"I wish to say definitely that to the investor in California today, the successful machine for long distance transmission of power electrically exists only in the minds of the inventors and promoters, or in some beautiful advertisement."

In 1891 the San Bernardino Light & Power Company constructed a 5,000-volt transmission line from its power house at Pomono, Cal., the line running 28 miles to San Bernardino. In 1892 the line was increased to 10,000 volts.

At the Ames, Colo., installation experiments and tests were made between 1890 and 1895, of pressures as high as 60,000 volts. At the Pomona project, the original voltage of 5,000 in November, 1892, was increased to 10,000 in February, 1893, and on May 2, 1893, by connecting transmission lines all in series, 120 kw was carried 42 miles with a transmission efficiency of 60 per cent, at that time a great achievement and an indication of the possibilities of electric transmission of power.

In 1891 power was transmitted from a water fall station at Lauffen to the city of Frankfort, a distance of about 100 miles. The transmission line used 30,000 volts, far above anything that had been used previously. This line achieved a great deal of publicity, but the installation was not a permanent one, being more or less an experiment to advertise an exposition going on in Frankfort.

The Lauffen-Frankfort line was 3-phase. Following its opening, there began two major technical battles—one of 3-phase versus 2-phase, and the other of frequencies. The phase controversy was stopped by the master stroke of Charles F. Scott, with his "T-connection" for transformers to connect 2-phase circuits to 3-phase circuits in balanced power relation.

First Polyphase A-C Transmission Lines

In 1892 the first commercial 3-phase alternating current installation, with a 10,000-volt transmission line 23 miles in length from Mill Creek to Riverside, Cal., was made. The installation consisted of two 250-kilowatt 2400-volt Y-connected generators, driven by Pelton Wheels. The plant and line were still in operation as late as 1934.

The year 1895 marked the beginning of the modern central station era and the recognition of the supremacy of polyphase alternating current for generation and transmission when the 5000-hp units began operation at Niagara Falls.

The electric equipment installed by the Niagara Falls Power Company in 1895 was unique in many respects. Primarily, it was unique in that it was intended for power instead of light, as had been most of the preceding installations. It was by far the largest electric power installation of the time. The methods adopted were new and untried—at least on the scale attempted at Niagara—namely, alternating current, polyphase. Practically all of the users of Niagara service were power users. The first user was the Pittsburgh Reduction Company, now the Aluminum Company of America, whose plant was started on August 26, 1895.

The Niagara electric generators were four times the capacity of the largest generators previously constructed. They were rated and were capable of carrying 5000 hp.

The first Niagara-Buffalo transmission line on the American side of the Niagara River went into service during the fall of 1896. The line was a relatively short one, only about 22 miles from the step-up station in Niagara to the step-down station in Buffalo. The voltage was not high—11,000 volts, 3-phase; other plants were at the time transmitting power at higher voltages. However, in some aspects the transmission was of historical interest. In the amount of power transmitted and in the importance of the service rendered, the Niagara-Buffalo transmission transcended anything that had been attempted previously. The first load in Buffalo was that of the street railways. Continuity of service was essential. It soon developed that the success or failure of Niagara power in Buffalo depended on keeping the supply continuously available in Buffalo.

Lightning was a formidable enemy, and required great research and development of protective insulation and arresters. The line was especially liable to interruptions owing to the severity of lightning storms on the Niagara frontier. Improvements came gradually but surely, and in recent years the company has gone the span of an entire year without a single interruption from lightning or any other cause.

Paul M. Lincoln, now Director, School of Electrical Engineering, Cornell University, who was electrical engineer and operating superintendent of the Niagara Falls Power Company from 1896 to 1902, had this to say about overcoming difficulties of this company's early transmission line:

"I might go on indefinitely giving instances of the difficulties we encountered on this early power transmission. They all lead to one conclusion: we were pioneers and we suffered the fate of all pioneers. The road we were traveling was not yet illuminated by the light of experience. We had to grope our way. We were not wholly unsuccessful in lighting the way for others to follow. The Niagara-Buffalo transmission was a success both from a financial and from an engineering standpoint. The battle for continuity of service was waged and won. It has always been a matter of no little self-satisfaction that we at Niagara have helped to blaze the trail that since then has become a much traveled highway."

Determination of Frequency

The development of hydro-electric power on a large scale at Niagara Falls forced the adoption of alternating current, only to be followed by great uncertainty as to the frequency to be used. Some authorities recommended 16.66 cycles per second. Other authorities felt convinced that eventually much of the vast power to be developed at Niagara Falls would have to be applied to continuous current machinery. The controlling engineers and executives of the project decided to launch it on a frequency of 25 cycles. As pointed out by Edward Dean Adams in his history of Niagara Falls, the 25 cycle frequency was a compromise.

Much work of all sorts remained to be done in the new electrical industry. Hydro-electric power in abundance was available on the Pacific Coast and the Intermountain Region involving trans-

missions to available markets over long distances. There quickly developed a need for standardization in voltage and current wave forms. Various frequencies were tried between the extremes then in use, 133 and 25 cycles. 40 cycles per second was tried at Portland, Ore.; 50 at Los Angeles and 60 at San Francisco. By 1915 the hydro-electric power transmission practice was stabilized at 60 cycles in the Far West and elsewhere.

High Tension Transmission Lines in 1908

The year 1908 saw the first evidence of the feasibility of transmission of voltages above 60,000 and in that year the first 100,000 volt line was installed. This was in the state of California, where the greater part of early installation of high tension transmission took place. This was natural, from the abundance of water power throughout the state, and from the fact that coal had to be imported from British Columbia or Australia, and cost in carload lots about $7 per ton. After 1895 oil became the standard fuel in California, but even as late as 1914 the price of oil, under ordinary conditions, was only 14 per cent cheaper than coal on an equivalent heat basis.

The first 100,000-volt long distance transmission line in the United States was installed by the Great Western Power Company from its Big Bend Plant, at Las Plumas, on the Feather River in northern California to Oakland, a distance of 155 miles. The Big Bend Plant was put into operation December 22, 1908, with four 10,000-kva units. The turbines were I. P. Morris 60-inch Francis vertical inward-flow machines, designed to operate at a speed of 400 rpm under a head of 525 feet. The 100,000-volt main trunk transmission line consisted of a single line of galvanized-steel towers, carrying two 3-phase circuits on suspended insulators, and included 1044 standard towers, and numerous smaller towers.

Commercial Development of the Transformer

In the eight years from 1894 to 1902 the maximum size of the transformer increased from 10 kilowatts to 2750 kilowatts, an increase of 275 times. The manufacture of these units also increased incredibly in this period, the total annual output increasing from 300 or 400 kilowatts to 250,000 kilowatts. The average size of the transformers increased from 10 kilowatts to 250 kilowatts in the period.

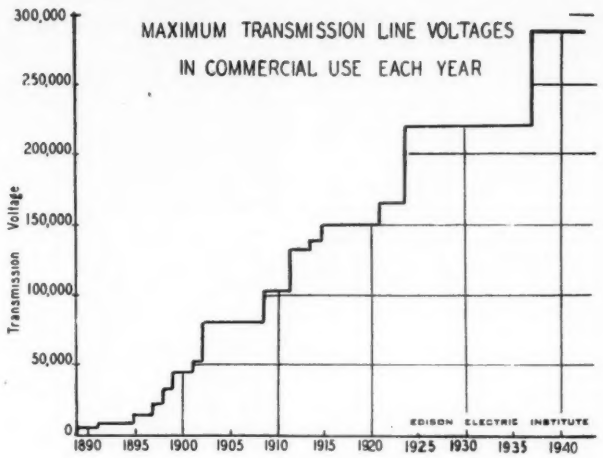

Fig. 4—Growth in Transmission Voltages

In a paper presented at the International Electrical Congress in St. Louis in 1904, Dr. F. A. C. Perrine said that natural groups of transmission length and voltage were somewhat decided by the manufacturers of machinery, who had presented as preferable certain available voltages. Above 2400 volts, "where transmission really begins" the first voltage commonly being employed in 1904 was 6600 volts, established as a standard by the needs of the lighting plants in the great cities. The next higher voltage, and practically the first one for which step-up transformers were used, was 15,000 volts.

The next step was to 25,000 volts, which was the highest figure reached without special study of insulators, switches and lightning arresters. A voltage of 33,000 was employed in a number of plants built about 1900, and at that figure special difficulties due to line capacity, insulator size, erratic lightning-arrester effects and switching began to make themselves seriously felt.

Above 33,000 volts the standard voltage in 1904 was called 60,000 volts, but the majority of plants actually operated at about 50,000 volts, being unable to operate at the 60,000-volt pressure on account of the character of the line insulators installed.

For years the power transmission industry was virtually forced to be content with 50,000 to 60,000 volt line insulators, the single pin-type insulator being thus limited, and which would not stand up under higher voltages. With dramatic suddenness the invention of the suspension type insulator made possible higher voltages for transmission lines. In 1908 in Michigan on a short line it was found that by the use of the latter type of insulators transmission of 110,000-volt, 3-phase, current was entirely feasible.

The General Electric Company reported the increase in voltages of transformers, based on orders received, as follows:

Year	*Volts*	*Year*	*Volts*
1891	3,000	1907	104,000
1892	6,000	1909	133,000
1894	12,000	1911	140,000
1896	22,000	1912	150,000
1897	33,000	1919	166,000
1898	44,000	1920	220,000
1900	55,000	1926	240,000
1901	80,000	1933	280,000

The beginning of operation of any of the above voltages naturally lagged one or two years behind the years given.

The number of available voltages continued to increase, until by 1922 there were some 30 different voltages classed as "normal" secondary voltage of the step-up transformers. In order to reduce the burden on the electric industry, simplify the practice, and encourage the development of standard apparatus and especially to facilitate interconnection of systems, certain voltages were adopted as standard by organizations representing the power industry and the manufacturers. These standard voltages were:

33,000	111,000
44,000	132,000
66,000	154,000
88,000	220,000

The first 60,000 volt transmission line was installed by the Bay Counties Power Company, between Colgate Power House, on the Yuba River and Oakland, a distance of 142 miles. The line was a double circuit. It was energized on April 27, 1901.

Early Price History of the Electric Light

When the "First District" of the Pearl Street Plant in New York City was lighted up in September, 1882, no charge was made for the use of the light. The directors were of the opinion that owing to the irregularity of the light, resulting from the imperfect governing of the engines, no charge should be made until the station was running light satisfactorily to their own engineers.

Although the British Electricity Supply Act of August, 1882, defined the "kilowatt-hour" as the Board of Trade unit for which the consumer had to pay for current, the term did not come into use in this country until 1889, the year in which the "watt" was given universal adoption by the International Electrical Congress held in Paris. From 1880 to 1884 the unit of current in the United States was termed the "weber,". In 1884 the name was changed to "ampere," and a unit of electrical power was called the "volt-ampere."

By the end of 1882 Edison had his engines running smoothly and the Edison chemical meter was put into use in 1882. This meter consisted of an electrolytic cell containing a solution of zinc sulphate with zinc plates for electrodes or terminals. It was limited to the measurement of direct current, and since all energy from the Edison stations of that day was supplied at a single constant voltage, it was satisfactory for some time to meter only the ampere-hour consumption. The company thereupon began early in 1883, to bill its customers, announcing:

"It is the present intention to make the bills for the light payable monthly, as it is the custom with gas bills, and to make the charge on the basis of $1.00 per 1,000 candles, which is equivalent to about the present price of gas ($2.25 per 1,000 cubic feet)."

A later bulletin of the Edison company, in 1883, stated:

"Our charge for light in the First District is at the rate of 1 and 1/5th cents per lamp per hour, consequently the product obtained by multiplying this price into the number of lamp hours shows what the consumer's bill for the light ought to be."

This rate would be the equivalent of 24 cents a kilowatt-hour.

Edison figured that "a lamp of 16-candlepower was the equivalent of a gas burner supplied with 5 feet of gas." Five feet of gas, at the prevailing rate of $2.25 per 1000 cubic feet, would cost 1.125 cents, so the first Edison charge of 1.2 cents per 16-cp lamp hour was a close equivalent. The price included the cost of the lamp.

For a 16-cp lamp burned 3 hours a day, the monthly cost at the Edison rate of 1.2 cents per hour would be $1.08, or $13 per year.

In the year 1883 the consumers were using an average of about 16 to 20 lamps each, of 16 and 8 candlepower. There were about 4 of the "A" (16-cp) lamps for every 3 "B" (8-cp) lamps on the lines. Consumers' bills ran to about $10 per month in the short evening summer months and about $15 and more in the winter months. The following shows a record of some months of Pearl Street plant operation in 1883, as to number of consumers, number of lamps and billings to consumers:

Month 1883	*Average No. of Consumers**	*Lamps In Use**	*Billings*	*Average Per Consumer*	*Average Per Lamp*
June	423	6,947	$5,204	$12.30	$0.75
July	440	7,687	4,530	10.30	.59
August	449	8,082	4,609	10.20	.57
September	463	8,395	5,062	10.90	.60
October	490	9,368	7,072	14.40	.75

* Mean average for the month.

The first Edison lamps were made "8 to the horsepower," equal to about 100 watts each, with an average lighting efficiency of 1.1 lumens per watt. Before Pearl Street opened they were being made "10 to the horsepower" and the wattage was 75, and had 2.25 lumens per watt initially.

In 1890 the Edison company in New York reduced its charge to 1 cent per lamp hour, the equivalent of 20 cents per kilowatt-hour. Discounts were offered for large customers, and the company was unique in that it published its complete schedule of rates and discounts.

Edison Wanted to Sell Light

Edison did not favor rates for current, as he wanted to sell "light." He said:

"The reason I wanted to sell light instead of current was that the public didn't understand anything about electric terms or electricity and had no confidence that they could ever learn; but they did understand light and it was light they paid for and we could make explanations which they could comprehend.

"Another reason I did not want to sell current was that from my experiments I knew that the incandescent lamp was only the beginning and that there were great possibilities of enormously increasing its economy, and I thought that the pioneers should reap some reward for these improvements. It was my idea that all the benefits which improvements in the lamp should attain, one-half should be given to the public and one-half given the company. But for some reason after a few years the selling of current was introduced, thus destroying all chances of the company's gaining any benefits from improvements; in fact such improvements were a disadvantage, which to my mind is a poor business policy for the company and the public."

In October, 1898, the Edison Company in New York City changed its rates to a "kilowatt-hour" basis, of promotional form, as follows: First hour's use, 20c per kwhr; second hour, 15c; third and fourth hours, 12c; and excess over four hours, 5c.

The spread to kilowatt-hour rates was rapid, being augmented by the development of accurate meters for measuring current used by the customers, and increasing power sales.

Many companies, especially the smaller ones, established flat rates per kilowatt-hour, regardless of the length of use or the quantity of current. The more progressive companies adopted load-factor rates based on the hours of use, and also quantity discounts for increased use.

A report of the United States Commissioner of Labor published returns of 952 electric central stations in the year 1897. The report gives for all stations the rates then in effect for both lighting and power. There were few companies supplying electric power, being only the larger sized companies.

A weighted analysis of the various types of rates charged by these utilities indicates the trend to kilowatt-hour rates within the years from 1890 to 1897. The following gives a condensed summary of the number of utilities and the average price charged according to the type of rate. A utility may have had two or more of these schedules in effect, and thus would appear under each of such types. All average prices are weighted by the size of the utility.

Rates for Incandescent Lighting:

(a) Rate per kilowatt-hour—426 utilities, or 45 per cent of the total; average rate 14.51 cents per kilowatt-hour;

(b) Rate per lamp per year (16-cp. equivalent)—500 companies, 53 per cent; average rate $8.10 per lamp per year;

(c) Rate per lamp hour—91 utilities, 10 per cent; average rate 0.63 cents per lamp hour;

(d) Rate per ampere hour—116 utilities, 12 per cent; average rate 0.90 cents per ampere hour.

Rates for Arc Lighting:

(e) Rate per arc lamp per year—722 utilities, 76 per cent; average rate $87.52 per arc lamp per year. In terms of rate per kilowatt-hour, averages 8.50 cents.

Under rate (e) the total number of lamps, the average hours burned per year, and the average price per lamp are as follows:

	Number of Lamps	*Average Hours per Lamp*	*Average Price per Lamp*
To commercial customers	25,934	2,108	$95.36
To municipality for street lighting	90,824	3,430	85.30
To all users	116,758	3,137	$87.52

Developments in Gas and Electricity Price Trends

As pointed out, Edison's first charge in 1882 for electric light was based on an equivalent cost for gas lighting, i.e. a 16-cp lamp being the equivalent of a gas burner supplied with 5 cubic feet of gas. The prevailing cost of gas in 1882, on which the charge was based, was $2.25 per 1000 cubic feet.

Gas lighting in New York City began in 1824 when the first private lighting was turned on—and public street lighting began in 1828. The original charge for the former was $10.00 per 1000 cubic feet, and for the latter $24 for a lamp-post and $8 per lamp per year for gas. Reductions came quite rapidly, the charge being $9 per MCF in 1828; $8 in 1829 and $7 in 1830. A second company entered the field in 1834 and began to offer lower rates than the original company, of $6 in 1836; $5 in 1838, and $4 in 1839—while the old company continued to charge its $7 per MCF. In 1850 rates were at $3.50 per MCF, and in 1855 down to $2.50. During the Civil War the rate was increased to $3 and to $3.50. In 1879 a rate war took place with the price dropping as low as 75c per MCF for large users, but in 1880 a pool agreement was reached by which a standard price of $2.25 was established—the charge met by Edison with his electric lamp.

Carl Auer invented his famous Welsbach gas mantle in 1885, which produced a light six times better than that of the old flat-flame or slip-tip burner. But the public at first looked upon it as a luxury and did not appreciate the advantages and savings inherent in its use. It was not until 1890 that it came into general use, but it was then too late to halt the progress of the rapidly expanding Edison incandescent electric lamp.

The competition was sufficient to worry the electric people, and even in New York City in the middle '90s there were districts in which the installations of Welsbach gas lamps was greatly exceeding those of the Edison lamps. The gas companies were installing the Welsbach lamps free and maintenance in first class condition was assumed, and were trying to switch over any electric customer whose bill exceeded $15 per month. But perhaps a major reason for the Welsbach spread was the drastic cuts in the rates for gas. In the 90's a bitter rate war developed between the three gas companies and in 1899 the prevailing rate was 50 cents per MCF.

Development in Lighting Efficiency

Three factors concurrently were aiding the Edison lights in keeping abreast with the lowering charges for the gas lights. These were: the price of the Edison carbon lamp, which, from 1880 to 1904, decreased from $1 to 20 cents each; the average efficiency of the lamp, which increased from 1 lumen per watt to 2.8 lumens per watt; and the decrease in the cost of producing current for lighting the lamps, which dropped from an average of 24 cents to 7 cents per kilowatt-hour.

In 1882 one cent would buy 50 lumens (5 candlepower hours) of the original Edison carbon lamp. In 1904 one cent would buy 360 lumens of the improved carbon lamp, or seven times as much light as in 1882.

In 1905 came the Gem lamp, which was 25 per cent more efficient than the regular carbon lamp of that time. It was also in the year 1905 that the rating of incandescent lamps was changed from a candlepower basis to wattage basis. The ordinary 16-candlepower carbon lamp consumed 50 watts of current and was so rated. The 50-watt Gem lamp gave 20-candlepower, both candlepower ratings being their mean candlepower in a horizontal direction. The Gem lamp was made in a number of sizes from 40 to 250 watts, but the 50-watt lamp was the most popular, many million of which were made before the lamp disappeared from use in 1918.

TABLE V—DECREASE IN COST OF LIGHT UNITS FROM 1882

Year	*Lumen-hours* For One Cent*	*Cost per Thousand Lumen-hours*	*Cost in Percent of 1882*
1882	50	20.00¢	100.0
1888	143	7.00	35.0
1894	220	4.55	23.0
1900	300	3.33	17.0
1904	364	3.02	15.0
1905	440	2.27	12.0
1906	501	2.00	10.0
1907	635	1.57	7.9
1912	1020	0.98	4.9
1914	1300	0.77	3.9
1915	1620	0.62	3.1
1923	1700	0.59	2.9
1933	2000	0.50	2.5
1937	2400	0.42	2.1
1942	3400	0.29	1.5

* For candle-power hours, divide by 10.

In 1906 there appeared the tantalum lamp, made with a filament of this metal. It had an average efficiency of about 4¼ lumens per watt. It disappeared from use in 1913.

While the inventors of the tungsten lamp had produced such a lamp in 1904, it was not until 1907 that they were put upon the American market, the first lamp put out being the 100-watt size for 110 volts. The efficiency of this lamp was 8 lumens per watt. Within a short time tungsten lamps of 60, 40 and then 25 watts were being made and sold in large numbers.

In 1911 was introduced the improved tungsten lamp, made with a ductile tungsten. In 1913 tungsten lamps were further improved by operating the filament in an inert gas.

The fluorescent lamp first commercially appeared in 1938 and has already shown considerable improvement in its efficiency after solution of the poor power factor problem, and the price has been lowered seven times in the four years since its introduction.

Major Changes in the Incandescent Lamp

The major changes in the incandescent lamp since its introduction in 1879 have been:

1879...Carbonized thread—carbon filament.
1879...Carbonized paper—carbon filament.
1880...Carbonized bamboo—carbon filament.
1888 ..Asphalted bamboo—carbon filament.
1893...Treated bamboo—carbon filament.
1894...Treated cellulose—carbon filament.
1905...Metallized carbon filament—GEM lamp.
1906...Tantalum filament.
1907...Tungsten filament.
1911...Drawn tungsten wire filament.
1912..."Getters" (chemicals used to improve the lumen maintenance).
1913...Gas-filled tungsten filament lamp.
1937 ..Coiled coil tungsten filament.
1938...Fluorescent lamp.

The combination of increased effi-

ciency in the lamp, reduction in the price of the lamp, and reduction in the price of current has resulted in giving the incandescent lighting user about 70 times as much light today as he obtained in 1882 for an equal amount of money. In other words, the cost of electric light today is less than 1½ per cent of the cost for an equivalent amount of light in 1882. The trend in the increase of number of light-units received for one cent at intervals from 1882 to 1942 has been as shown in Table V.

The figures for the later years are based on the standard 60-watt Mazda lamp; larger wattage lamps have much higher efficiencies than shown, and smaller lamps lower efficiencies. All figures are based on the prevailing lamp prices, lamp efficiencies and rates for current as of the years shown.

Motors and Diversified Electric Service

Even before Edison invented his central station system he was positive that power would eventually be as important as light. In an early notebook (1878) he said:

"It doesn't matter if electricity is used for light or for power. Small motors can be used night or day and small steam engines are inconvenient."

This was quickly recognized by others. For example, in 1881, President Thurston of the American Society of Mechanical Engineers, in his second annual address to that body, referred to Edison's new dynamo which increased efficiencies to 90 per cent from the former 40 to 50 per cent dynamos.

"It follows at once that mechanical power may be transmitted through two such machines, again appearing as mechanical power with a loss of less than 20 per cent. And it follows from this last fact that the distribution of power by electricity is not unlikely to prove *a more important application of this wonderful force than is the electric light.*"

When the Pearl Street plant opened, Edison was already busy designing electric motors for customers' use. A bulletin of the Edison Company of New York in December, 1882, said:

"Regarding the selling of power in the First District, Mr. Edison is now engaged in constructing motors of different sizes. We expect a large demand for power and now that selling of light has been successfully started, special attention will be given to equipping the District with facilities for furnishing power."

But it was not until 1884 that saw the beginning of diversification of electric sales, for in that year the first electric fan motors went on the circuits and various motors were introduced for industrial uses. Diversified power had begun.

By 1886 electric motor power was being sold by a station in Boston. The Daft Electric Power Company, from its dynamos at a central station, was supplying electric power to about 30 motors in various parts of the city.

"It is sold at $150 per horsepower per year, the price at present being about the same as that for steam for small powers."

Rates for motor power began to come down as its use spread. In 1887, charges for motors in Boston were on a monthly basis, of which the following were typical:

Size of motor	*Rent of Motor*	*Cost of Power*	*Total cost per Year*
⅛	$0.50	$3.00	$42.00
½	1.00	5.00	72.00
1	1.00	8.00	108.00
4	5.00	26.00	372.00

In Kansas City charges were slightly higher, with a rate of $96 per year for a motor of ½ hp.; $150 for 1 hp.; and $360 for a 3 hp. motor.

Progress Slow at First

For two decades the motor business progressed but slowly. Motors were small and their use was confined to few applications, mainly elevators, printing presses, sewing machines, fans, organ blowing, lathes, coffee grinding, etc. As late as 1899 a study showed that the average electric motor was about 5 horsepower. Lathe motors ran as high as 8½ hp.; the usual elevator motor was 7 hp.; for printing, about 6 hp.; and sewing machine motors averaged 4 hp.

The year 1893 saw the historic installation by General Electric Company of a dozen or so "huge" 65-horsepower alternating current motors in the textile mills at Columbia, S. C. In 1907, motors of 6500 horsepower were being installed in the Gary Steel Mills at Gary, Ind.

In the report of 1897 of the Commissioner of Labor it is shown that of the 932 central stations, 266 were supplying electric power for motors as well as for lights, and 686 supplied light only. Of the 632 privately owned central stations, 244 rendered service to both light and motors, while 388 stations supplied current for light only. Of the 320 municipal plants, 22 supplied both light and motor service, and 298 supplied light only.

Although the total power in the manufacturing industries in the year 1899 amounted to 13,488,000 horsepower, only 182,000 hp of this was for motors run on energy purchased from central stations, or 2 per cent of the total. By 1909 the percentage had jumped to 9 per cent; in 1919 to 32 per cent; and today the percentage is 58 per cent.

Study of the Association rate books of 1903 and 1904 indicates that the central stations were trying out various methods of charging for motor power, but that most of the stations in the large cities had rates based on hours use, with sliding scales. Maximum rates began at between 10 and 15 cents per kilowatt-hour, and graduated down to various minimum amounts, some as low as 2 cents. Electric railway power was being quoted at 2 to 3 cents per kilowatt-hour.

The Bill that Failed to Pass

In the 1889 legislature of Virginia a bill was introduced—which, if adopted there and elsewhere, would have completely stifled the development of high tension alternating current transmission. The bill provided:

"The electric pressure shall not exceed the following amounts: The non-pulsating continuous current to a pressure not exceeding 800 volts; the pulsating continuous current to a pressure not exceeding 550 volts; the alternating current to a pressure not exceeding 200 volts, according to the nature of the current used."

Hearings were held on the bill by the Senate Committee to consider the bill, and distinguished witnesses appeared—including Thomas Edison, who appeared on behalf of the passage of the bill. Westinghouse retained President Morton of Stevens Institute of Technology. Edison had said in effect that the continuous current was like a river flowing peacefully to the sea, while he compared the alternating current to a torrent rushing violently over a precipice. Dr. Morton suggested that it would be more accurate to compare the continuous current to water flowing in one direction through a pipe, and the alternating current to water moving first in one direction and then in the opposite direction in the same pipe.

Fortunately for the development of water power and the successful transmission of high tension power to the factories of this country, the Senate Committee on General Laws of Virginia recommended that the bill be not passed, and the bill was killed. Many of the companies throughout Virginia supplying arc lighting to the towns and cities were using 3000-volt potentials, and the bill would have put them out of business.

Early Troubles of the Power Engineer

From an unpublished letter of the late Alex Dow to Charles E. Neil, author of the preceding article. At the time of his death in March of this year, Mr. Dow was Chairman of the Board of The Detroit Edison Company. He had been with that company and its predecessor company from 1896.

"I broke permanently into the electric light business in January of 1888, in the City of Baltimore. The outfit that I joined ran a series circuit, approximately 10 amperes, for meters, 24 hours a day excepting Sundays. There were some arc lamps on the same day circuit. Incandescent lighting circuits were turned on at dusk and run until daylight. The big snowstorm which by Eastern people was miscalled a blizzard, did not put us entirely out of action but did make a big mess of trouble. All service was sold at flat rates—so much per horsepower per annum, or so much per lamp per month. The Edison plants elsewhere had used chemical meters. The Westinghouse Company had just produced a sort of induction meter which registered energy 'within four rows of apple trees.' The Thomson-Houston people had developed but not perfected a motor meter designed by Professor Elihu Thomson, a good one.

The Most Unreliable Item

"During my first years of service the incandescent lamps were the most unreliable item. Their life was uncertain. Most of them in Baltimore in 1888 were strung in series of five lamps, and when one went out all five went out. The Company had to keep always one man and sometimes two on duty, with bags of lamps to respond to calls of 'lights out.' One man did not like to carry those bags; and being ingenious, he got his wife to fix up the lining of his winter overcoat so he could fill the skirt of it with lamps. Whereby there was a funny happening. There was a sad tragedy on the stage in the Academy of Music. The man with the packaged overcoat was, of course, a free entrant. He went in there, looked down at the show from the rail at the back of the pit and stooping, tempted the city fireman who was on duty, according to law, in the theatre, to give him a sharp swat over that portion of his anatomy which projected during the stoop. The slow music of the tragic scene was just beginning when about twenty lamps exploded and there was almost a panic in the theatre.

"I kicked around doing wiring, learning the ways of engines, etc., until I became responsible for the engineering end of a sales district of one of the older manufacturing companies. There I chased lots of trouble. The very first thing that was wished on me was a locomotive type headlight with a 20 ampere arc, on a Mississippi raft boat, which persisted in pulling an arc so long that it presently broke the circuit and put out the light. I was badly puzzled by the symptoms. I had no volt meter and an unreliable ammeter. Finally I suspected the speed and discovered that the small generator had the name plate which belonged to another machine and was being run 50 per cent too fast.

Weather Interruptions

"About weather interruptions—All of the lines for which I was responsible either as builder or operator were substantially built with so-called weatherproof wire, which wire was insulated with a cotton braid soaked with ozocerite. Voltages were low but high enough to make trouble when the wind broke off small branches of trees in wet weather and threw these across the opposite wires of a circuit. Lightning smashed insulators occasionally and in some districts would split a pole, but the lines stood up quite creditably. The meters, however, and motors and the early transformers were easy marks for lightning. On one three-wire system I found that I lost so many meters by having their potential circuit punctured that I put a 16-turn choke on each service wire. The supply was direct current and the choke did not materially reduce the voltage but it checked any secondary surge due to lightning. At the end of all branch lines I put an old fashioned lightning arrester. Then, in 1897, I went on the war-path for lightning-proof meters and ultimately got them.

Transformers

"As to transformers.—Sometime in the eighties Professor Elihu Thomson invented the safety shield which he put between the primary and secondary winding of his transformers, connecting the shield to earth, thereby putting an end to the primary current breaking through into the secondary and getting into customers' premises. The next big improvement in transformers was filling the cases with insulating oil. These Thomson inventions very much reduced the damage by lightning to transformers and the present day transformer is immune to anything but direct stroke. When you get a direct stroke you still just go and clean up the mess. Squirrels and 'coons still short-circuit a terminal occasionally putting out lights and going to animal heaven in bad order.

"Early underground cables were far from reliable. Electrical engineers had not yet discovered the different requirements for high electrical resistance, and immunity from puncture by surges. I remember certain street lighting cables on the West side of Chicago, which gave beautiful bridge tests but which punctured everytime a generator flashed over—and the generators did so quite frequently. Every time those cables punctured each of the old style grounded-return telephones in the district went out of action; and telephones were then coming into general use.

When the Customer Rejoiced

"While I was engineering for that long ago manufacturing company I installed a 220-volt, 3-wire direct current system in a small Michigan City, in competition with an alternating current service, which had oodles of transformer trouble. The transformers were of the hedge-hog type long ago forgotten. I made my customer put plenty of earth connections on the neutral wire. I told him also that the particular machines that generated his direct current would be just about immune to injury if his wires happened to be crossed with the alternating current wires of his competitor, whereas the alternator and the transformers would be damaged by the direct current if the cross came on a rainy night. The happenings were exactly according to my prediction. My customer was just mean enough to rejoice everytime that a wind and rain storm came along and these were—and are—quite plentiful in that district."—ALEX DOW.

What of Tomorrow?

A Suggestion from the Electric Water Heating Committee

By C. M. Turner, *Chairman*

"The prudent will prepare themselves to encounter what they can not prevent."

THIS word of wisdom from the writings of James Russell Lowell is being heeded by many industries and many utilities.

Electric utilities may not be able to prevent a sudden and possibly complete collapse of their service to war industries and training camps when hostilities cease, but they can prepare themselves to encounter such curtailment.

Although there are two opposing schools of thought with respect to post-war economic conditions, one contending for a boom era and the other for economic disaster, a safer and middle-of-the-road belief is that this war will be followed by first a short slump until factories can change to the production of civilian goods, next a period of moderate prosperity for replacement of worn-out equipment and facilities, and then a depression of unknown length. Study of past situations indicates that regardless of the shape of the pattern, we will be in the doldrums sooner or later. Come that day, the utilities again will be appreciative of their domestic business. Preparation, well in advance of any recession, of a promotional program in which the automatic electric water heater plays a key role will reflect favorably in the utility's net revenues at a time when most needed.

Two Obstacles to Overcome

In preparing to meet the advancing depression cycle, the utilities must plan to overcome two obstacles in the path of their sales program first, decrease in customer's purchasing power, and second, shrinking of utility promotional funds. These obstacles are of major concern to the utility executive because he may feel that the "low ebb" of both customer's purchasing power and utility's promotional funds during the post-war valley are matters which he is in no position to alleviate. But this is not true. Much can be done to meet lowered purchasing power and curtailed promotional activities of the future if an effort is made *now* to do it.

This discussion is directed chiefly toward the means for meeting lower purchasing power of customers. However, before dismissing the associated problem of diminished promotional funds, it should be emphasized that developmental effort might be made during the interim between now and the post-war period in order that a market may be created in advance of the expected slump. The potential market lies in the *minds* of the people—it is the favorable *attitude* of people toward electric service as a necessity. If the industry is successful in creating such a strong desire for electric water heating prior to the post-war era, then the problem resolves itself mainly into the matter of providing equipment which the prospective customers will be willing to purchase with their reduced incomes.

Some Benefits of Water Heater Standardization

To Manufacturer

Better price and delivery on purchased materials and parts
Lower inventories of complete apparatus and parts
Less engineering
Larger production runs with more economical operation and less time lost in change-over
More stable labor condition
Lower tool investment
Greater flexibility of manufacture
Assurance of uniform quality
Accelerated development of the product
Cumulative savings to offset increase in uncontrollable costs or to provide lower selling price

To Distributor and Dealer

Better deliveries
Lower inventories
Fewer repair parts
Smaller warehousing area
Lower overhead
Simplified selling
Lower cost and selling price
Better competitive position with non-electric water heaters
Greater turnover

To Consumer

Assurance of quality merchandise
Assurance of reliable operation
Lower appliance cost
Better delivery
Lower installation cost
More prompt and cheaper servicing

To Utility

Better competitive position with fuels
Broader market
Greater sales of service
Maintenance of load as result of prompt and cheaper servicing
Better customer relations

Meeting Reduced Purchasing Power

Unknown, perhaps, to many of the executives who have been assigned to think primarily of tomorrow's plans is the concentrated effort of several groups of men working to achieve what it will take to meet the challenge of lower purchasing power that is to come. Based upon the very practical theory of Henry Ford that standardization permits mass production and mass production means reduced costs which in turn create demand, these men are streamlining the electric water heater in a way that will assure minimum prices in the future.

The National Electrical Manufacturers Association has been considering the possibilities of standard units for years, and from time to time has established for use of members certain standards of wattages, voltages, color coding of wiring, and the like. A joint NEMA-EEI committee in 1938 completed a set of test specifications for trial purposes, omitting all but a few minimum performance values (EEI Publication F-8). Consideration is now being given to establishment of additional performance values important to utilities and customers, after many months of experience on the part of utilities and manufacturers.

For over two years the EEI Electric Water Heating Committee has been studying standardization of water heating equipment from the viewpoint of the electric utility and recently published its recommendations (EEI Publication I-5).

A survey of utility companies was conducted to determine, among other things, the degree of acceptance of the standards of manufacture set up by NEMA and shown in the diagram in Fig. 1. Acceptance, as demonstrated by the replies from 103 companies, was nearly 100 per cent with respect to wattages, voltage,

thermostat settings and thermostat differential. Approval of the ratios of wattage to tank size was not so general, but better alternatives were not forthcoming. Based on the report of the Water Heating Committee, the General Sales Committee, predecessor of the present General Commercial Committee, passed a resolution recommending the adoption and support of the NEMA standards and joint EEI-NEMA test specifications by the utility industry. The resolution is printed on the next page.

Since the printing of the Committee's report in October, 1941, the American Standards Association has established a committee on electric water heaters. This ASA committee, under the chairmanship of Dr. Earl C. McCracken, Columbia University, is composed of representatives from consumer groups, government bureaus, dealer associations, testing laboratories, manufacturers, electric light and power interests, and others.

In brief, that is the development of the activities for standardizing electric water heating equipment to date—all action focusing on the goal of providing greater comfort and convenience to more families at less cost. The benefits of water heater standardization are listed in part on the first page of this article.

Survey of Manufacturers

So much of a general nature has been said with respect to "standardization" of electric water heaters and its benefits that it may be refreshing to learn *why* it is so beneficial and *why* it should help in establishing this phase of domestic service during the post-war valley when unlimited production can be resumed. Water heater manufacturers of NEMA were contacted in a recent survey to determine just why the electric utilities and their customers may expect to benefit—in good old dollars—if there were in general use standard types of water heaters. Here is the story of how adopted standards may bring mass production —thence lower prices—thence greater demands for the product—and around and around again:

Engineering

Standardization will reduce substantially the amount of drafting and design work required for special jobs. Complete standardization will eliminate all "shop orders" which cover deviations from standard specifications. One company reports that during the past three years, even after certain standards had begun to take shape, shop orders accounted for 11 per cent of the total water heaters manufactured, with an average of only six per order. This company states: "Such orders require special handling from the time of their receipt until they are actually shipped. . . . "

Standardization also will reduce the amount of laboratory testing necessary to determine effects of special requirements on operating characteristics. In one report it was indicated that a complete laboratory test of any one capacity requires approximately 30 days' time. Testing of any particular wattage combination, or of particular thermostat calibration, requires three or more days each.

One of the reporting manufacturers believes that standardization sufficient to eliminate special design will reduce engineering costs by at least 50 per cent, and will permit the staff to develop better products for less cost.

Purchasing

Savings in the Purchasing Department will not be in direct proportion to the amount of standardization effected because of the number of common parts used. However, there is reported an anticipated saving of at least 10 per cent on quantity purchases, as well as savings accruing from reduction in the number of items necessary for the purchasing agent to order and follow.

Warehousing

Warehousing costs will be affected at two points: first, materials and parts; and second, finished stock. Considerable savings will result because material and parts will turn-over faster. Paper work will be reduced and simplified. Inventory investment and labor to handle it will be reduced and made more effective. One company suggests that it needs 40 to 45 per cent more space to house parts required by the multitude of "specials" than would be necessary to float the same production of a standard line.

Finished stock inventories will be reduced because of the short time necessary to convert raw materials into fin-

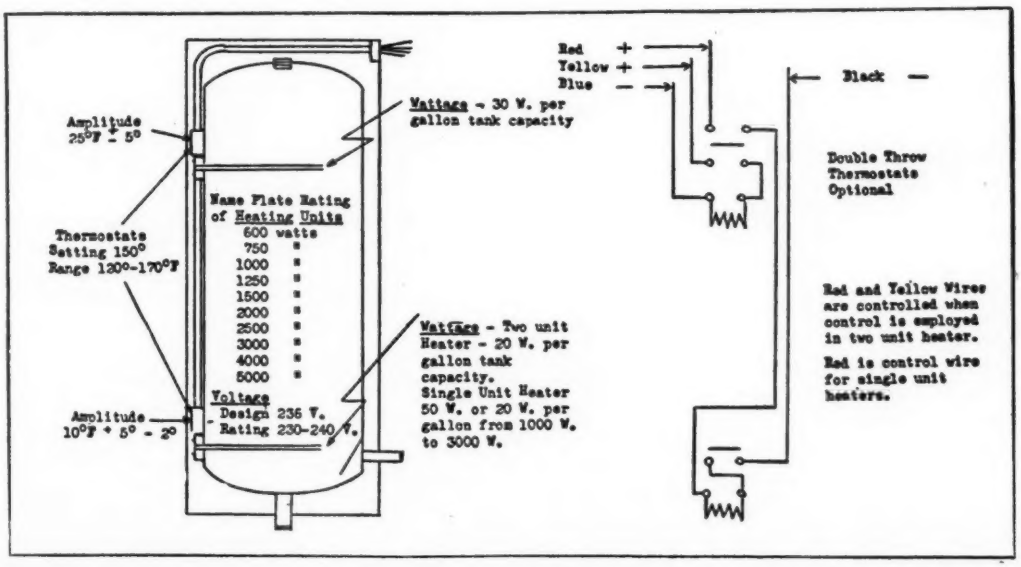
Red +
Yellow +
Blue —
Black —
Voltage - 30 W. per gallon tank capacity
Amplitude 25°F ± 5°
Name Plate Rating of Heating Units
600 watts
750 "
1000 "
1250 "
1500 "
2000 "
2500 "
3000 "
4000 "
5000 "
Thermostats Setting 150° Range 120°-170°F
Voltage - Design 236 V. Rating 230-240 V.
Amplitude 10°F ± 5° - 2°
Voltage - Two unit Heater - 20 W. per gallon tank capacity. Single Unit Heater 50 W. or 20 W. per gallon from 1000 W. to 3000 W.
Double Throw Thermostats Optional
Red and Yellow Wires are controlled when control is employed in two unit heater.
Red is control wire for single unit heaters.

Fig. 1—Current Standards for Single and Two Unit Electric Water Heaters Adopted by NEMA and Recommended by EEI.

ished products on a standard production line. One manufacturer estimates that a reduction in warehouse space could be as high as 20 per cent at the factory and that warehousing of some distributors might be reduced as much as 50 per cent, particularly in cases of distributors who find it necessary to carry as many as three or four special requirements.

Some manufacturers of water heaters find that it has been more economical to partially assemble some water heaters on the production line and then store them without heating units, thermostats or wiring. This means that both the heater and the crating must be so designed that these parts may be added later to fill orders for off-standard specifications. Other manufacturers point out that tanks can be pressure tested only with heating units and tank fittings in place, thus adding a complication difficult to surmount. Because of the seasonal flow of orders, this special assembly, where used, works at less than capacity in some weeks and is greatly overloaded in others.

Labor

The large manufacturers have set up their shops with modern streamlined production facilities which can operate at best efficiency only if they are permitted to function continuously. Interrupting the production line to turn out special requirements for particular customers means time lost for changing assembly lines, and increases the amount of time and effort necessary to check material in and out of stock for such changes. The more continuous the run of standard water heaters, therefore, the greater the savings in production labor.

It is felt that standardization will also result in a saving through improved inspection and production line testing, inasmuch as straight line production brings familiarity through repetitive operations.

With respect to indirect labor costs, there probably will be no reduction in supervisory expense, but as one manufacturer states, "the foremen, instead of trying to keep up with the engineers in the rapid 'minor' changes of design, could concentrate on cutting their costs in their respective departments and increasing their output."

Overheads

The matter of overheads is more difficult to analyze, but some of the manufacturers had no hesitancy in stating that the overheads will be reduced at all points except where direct labor and supervision are concerned. One company in particular believes that overhead per water heater can be drastically reduced with the general adoption of NEMA standards by the utilities.

Clerical

Due to the accumulation of savings all the way from the purchasing of material through the sale of the finished product, there will be a reduction in clerical expense per appliance unit. Lower production costs will mean lower selling prices and will result in creating a greater demand for the product. Greater demand will increase the number of units to be handled by clerical forces, but because of the standardization which helped to create this increased demand, it is indicated by more than one company that at least 25 per cent more business could be handled by the present clerical forces without any additional expense.

Commercial

All of the companies foresee considerable reduction in the cost of commercial operations, particularly since sales presentations on standard heaters will contain less technicalities than are now needed where there is no universally adopted standard. It will make selling easier and place it on a quality basis. To the extent that standardization simplifies the distributor's inventories and therefore reduces his overhead and at the same time increases his margin of profit, the distributor management will give more attention to the promotion of electric water heaters, and this undoubtedly will result in increased volume. Standardization will mean less in the way of direct savings to the individual dealer, of course, but he would be the logical recipient of increased effort by both the manufacturer and the distributor and would benefit greatly by resulting increased volume. It naturally is expected that savings effected in the manufacture of water heaters will be passed on consecutively to the distributor, the dealer and the consumer, thus creating a greater demand, cutting sales resistance and automatically lowering the cost of sales. In other words, reduced production costs will also reduce unit sales costs.

(*Continued on page* 356)

A Resolution of the EEI General Sales Committee on Standardization of Electric Water Heaters

Adopted November 14, 1941

WHEREAS the Electric Water Heating Committee has concluded an extensive survey of electric water heating methods, including equipment design, and has gathered comprehensive information regarding the practices of many utilities, the summary of which discloses wide interest in, and a vital need for, standardization; and

WHEREAS a Joint EEI-NEMA Committee has previously established a Test Specification thus laying a foundation for standardization in equipment design, which testing methods have been widely used and proved acceptable; and

WHEREAS in the light of these endeavors, and as the result of similar study, the Electric Water Heating Section of the National Electrical Manufacturers Association has adopted certain standards for design of electric water heating equipment, which standards are shown by the survey recently conducted by the Electric Water Heating Committee to be acceptable to a majority of utilities contacted;

BE IT RESOLVED that this Committee recommends to the members of the EEI and to other electric utilities the adoption and active support of:

—the Joint EEI-NEMA Test Specifications (EEI Publication No. F-8)

—NEMA standards affecting design features of automatic storage type electric water heaters (EEI Publication No. I-5)

because these specifications and standards tend toward lower cost in selling, handling and supplying of service, as well as in manufacturing, warehousing, distributing and selling of equipment, and tend toward improving the complete service rendered the consumer.

BE IT FURTHER RESOLVED that in view of the present emergency defense situation, adoption of the standards referred to becomes highly important

—to the utility, because of the possibility of lowering electric demands being imposed on its system

—to the consumer, because of the resulting lower cost and greater efficiency of equipment, and

—to the manufacturer, because of the possible improvement in the utilization of available materials and facilities.

Non-Metallic Sheathed Cable Wiring

Under Code Amendment Nos. 43 and 44

By E. S. McConnell
Edison Electric Institute

THE natural development of the electrical wiring art has resulted in about a dozen different wiring methods, but nearly all of them fall into one or the other of two general classifications.

1. The first class is typified by knob-and-tube work and conduit wiring. In these wiring methods, which are inherently based on the use of seperate insulated wires, the number of conductors and their appropriate identification can be readily arranged to suit the particular circuits under consideration.
2. The second class consists of self-contained assemblies, such as non-metallic sheathed cable or armored cable, which is usually required and until recently has been available in two and three conductor cables with all wires fully insulated and with one wire identified as the grounded conductor by having a white braid or finish.

Ever since cable assemblies were recognized in the National Electrical Code, we have had two and three conductor cable assemblies and they have met our needs very nicely, for when four or more conductors were occasionally needed all that was necessary was to run two pieces of cable in parallel. Non-metallic sheathed cable was particularly well adapted to this usage, for having a non-metallic sheath there was no necessity for enclosing all of the conductors within a common sheath in order to avoid inductive heating that would otherwise occur in a metal enclosure. In those occasional instances where it was convenient to use the identified wire as an ungrounded conductor, a special rule in the Code (Section 2006) permitted this use, because the identified wire was fully insulated and it was thus perfectly feasible to use two conductor cable for a single pole switch loop or a three conductor cable in a three-way switch circuit.

Because of the war and the necessity of conserving materials wherever possible to do so, several Interim Amendments to the National Electrical Code have been adopted. Like other new things, these changes have presented new problems for contractors, wiremen, and electrical inspectors. For example, Interim Amendment No. 44 provides that the grounded conductor in any of the conventional wiring methods need not be rubber insulated, but may be weatherproof, slow-burning weatherproof, or other types especially approved for the conditions. The object of this amendment is to conserve rubber, for after all rubber is not necessary for a grounded conductor. About the same time the War Production Board, in one of their orders pertaining to rubber conservation prohibited the use of rubber insulation for the grounded conductor of 0-600 volt A-C wiring systems. (WPB Order M-15-b-1 Amendment 8, July 10, 1942.) The net result of these two actions is that we no longer have the former standard two and three conductor cable assemblies with all conductors fully insulated. Now some other means must be taken to provide for the circuits where we have heretofore made use of the insulation on the identified conductor.

Another example is Interim Amendment No. 43 which adds new Section 3372 to the Code providing for the use of non-metallic sheathed cable having one circuit conductor without individual insulation and which may be used for the same general purposes as standard non-metallic sheathed cable. This amendment, of course, provides for the use of Covered Neutral Cable which has been used for the past seven years in many different sections of the country under the trial installation procedure.

As a result of these two Amendments we now have two new types of non-metallic sheathed cable assemblies approved in the Code and available for use:

1. Non-metallic Sheathed Cable with one or two insulated conductors and a weatherproof or similarly covered conductor identified for use as the grounded conductor.
2. Covered Neutral Cable such as Type CNX with one or two fully insulated conductors and an un-insulated neutral under the overall protective braid. It is our understanding that two somewhat different constructions of Covered Neutral are being made available by the manufacturers. One of these is Type CNX wherein the neutral is concentrically stranded around the insulated conductor(s). In the second construction the un-insulated neutral is laid parallel with the insulated conductor(s).

For all practical purposes, these two general types of cable assemblies are very similar. Weatherproof or similar covering on the identified wire can not be depended upon as having a definite insulating value and especial care must be taken that is is not confused with an insulated wire. The conventional type of Non-metallic Sheathed Cable, which ordinarily had all conductors insulated, automatically becomes "covered neutral" in the essential meaning of that term, as soon as some other covering is substituted for the usual insulation on the neutral. Therefore, a cable with the neutral conductor covered with slow-burning or weatherproof braids and finish, falls in the same category as a cable with the neutral conductor bare but protected by the standard non-metallic "sheath" which is adequate protection under any condition where the weatherproof or slow-burning covering is adequate. Consequently, the problems of wiring lay-out and the installation of circuits requiring two or more insulated wires are identical with both types of the new cable assemblies recognized by Interim Amendments Nos. 43 and 44.

Now let us examine some specific circuits where two or three insulated conductors are required.

1. *Switch Leg* (Fig. 1 and 2): An outlet controlled by a single pole switch may be wired in either of two ways; that is, when the feed is through the switch or when the feed is through the outlet. When the feed is through the outlet, the common practice in the past has been to use two conductor cable with both wires fully insulated, the Code requiring that the unidentified conductor be the return conductor from the switch to the outlet (Section 2006 b). Now that we no longer have two conductor cable with both wires insulated, there are two perfectly good ways of handling the problem:

(a) Perhaps the simplest way to handle the problem is to arrange the wiring lay-out so that the feed is through the switch (Fig. 1). When this is done the identified, and now un-insulated, conductor runs through the switch box to the outlet. A receptacle outlet or pilot light can be added at the switch location because the grounded conductor is already there and available for this use if desired.

(b) A second way of handling the problem, when the feed is through the outlet, is to use three conductor cable (Fig. 2). In this manner the two insulated conductors of the cable are available for the two wires of the switch loop, both of which are alive

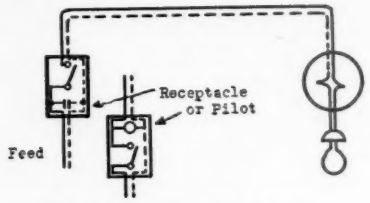

Fig. 1—Single Pole Switch—Feed Through Switch.

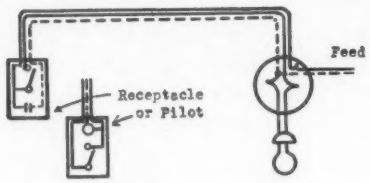

Fig. 2—Single Pole Switch—Feed Through Outlet.

Fig. 3—Three-Way Switch—Feed-Switch-Switch-Outlet

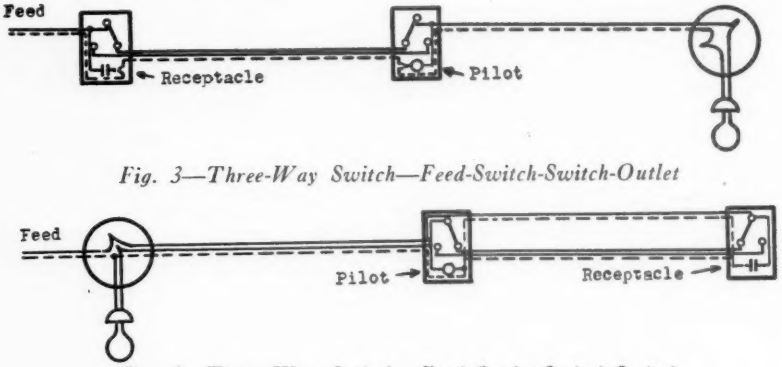

Fig. 4—Three-Way Switch—Feed-Outlet-Switch-Switch

Fig. 5—Three-Way Switch—Feed-Switch-Outlet-Switch

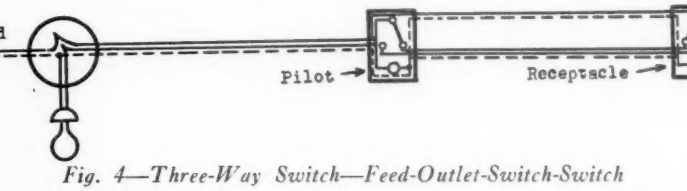

Fig. 6—Three way switch:
Switch—{Outlet / Feed}—Switch

when the outlet is energized. Then if desired, the identified conductor may be used for a receptacle outlet or a pilot light in the same single gang switch box.

It is perhaps worth noting in connection with this second way of handling a switch loop that the possibility of adding a convenience outlet in the switch box is particularly pertinent at this time because of the limitations on the number of outlets contained in the Defense Housing Critical List. Under the provisions of the Critical List a combination outlet, such as a switch and convenience outlet, are counted as one outlet. Thus it is feasible to provide a receptacle outlet that could not otherwise be installed. Anybody who has ever used a vacuum cleaner will testify to the convenience of having a reecptacle outlet at switch locations, even when baseboard outlets are available.

2. *Three-Way Switch* (Figs. 3 to 6): There are no less than four different ways of connecting a three-way switch circuit depending upon the sequence of the feed, the outlet, and the two switches. In three of these circuit arrangements, Figs. 4, 5, and 6, one or both of the switch circuits will require three insulated conductors. And most of us have not yet become accustomed to the idea that we no longer have cable assemblies with three insulated conductors, so it does present something of a problem. However, as in the case of a single pole switch, there are at least two good solutions to the problem:

(a) If it is practical to arrange the circuit so that the sequence is "Feed-switch-switch-outlet," then the circuit between the two switches will require three wires, only two of which need be insulated. The third wire is the grounded conductor which runs straight through from source to outlet; and being available in each of the switch boxes, makes it feasible and extremely convenient to add a receptacle outlet at one switch and a pilot light at the other switch as shown in Fig. 3.

(b) If some other sequence of the circuit is necessary, then one or both switch circuits will require three insulated wires and the problem becomes more complicated. However, if non-metallic sheathed or covered neutral cable is used, the circuit can be made of a combination of a two conductor cable and a three conductor cable placed in parallel in order to provide the three insulated conductors. Although one of the identified conductors will be superfluous, the other is available for use in providing a receptacle outlet or pilot light at the switch locations as shown in Figs. 4, 5, and 6. Although this arrangement of using two cables in parallel may at first seem cumbersome, it really offers a definite advantage, for with the use of the former type of three conductor (all insulated) cable, a grounded conductor in the switch box was not available for pilot light or receptacle outlet.

3 *Switched Receptacle Outlets:* Although switched receptacle outlets add a great deal to the electrical adequacy and convenience of living in a house, they must be considered in the luxury class today. But that need not deter us from considering the problem briefly. Some combinations of switched receptacles controlled by a pair of three-way switches may require as many as three or four insulated wires and a grounded wire in some portions of the circuit. This can be easily taken care of in the same manner as with a three-way switch by using two cables in parallel. Although one of the identified wires will be superfluous, it may be connected in parallel with the other grounded conductor. Again that neutral wire provides the advantage of a receptacle outlet or pilot light at switch locations which would not otherwise be practical.

Until such time as usage indicates a definite preference for one construction of cable assemblies over others, it appears that we shall have at least three different constructions of non-metallic sheathed cable in both two and three conductors as follows:

1. Non-metallic sheathed cable having a weatherproof or slow-burning weatherproof wire as the identified conductor. A cable of this construction will have the same dimensions, weight, and appearance that we have been accustomed to heretofore. However, it is necessary to remember that the identified wire is no longer insulated and cannot be used in those locations where we have been in the habit of making use of the insulation.

2. A construction of Covered Neutral Cable wherein the un-insulated conductor is laid parallel with the insulated conductor(s). In a three conductor cable this construction will be oval in shape and similar in size and weight to the former two conductor wire. The two conductor cable of this construction is somewhat oval in shape, but is smaller,

lighter, and easier to handle than non-metallic sheathed cable.

3. A third construction is the now familiar Type CNX Covered Neutral Coble, wherein the grounded conductor is concentrically stranded around the insulated conductor(s).

Covered Neutral Cable has approximately two-thirds the size and weight of non-metallic sheathed cable having weatherproofed or similarly covered wire as the identified conductor. It has the further advantage that two conductor cable is round in shape, very flexible, extremely easy to handle, and therefore less subject to damage during installation.

Type CNX construction has the further advantage that circuit protection is facilitated by the concentric arrangement of the grounded conductor which surrounds and thus protects the insulated conductor with a metal envelope of low resistance. This low resistance grounded conductor insures the prompt operation of the over-current protective device in the event of a wiring fault. The stranded un-insulated neutral also facilitates correct polarization because it is impossible to confuse it with a covered or insulated conductor usually solid. As one electrical inspector once summed up the matter, "A blind man working in the dark of a strange garret couldn't make a mistake."

Non-metallic wiring methods are one of the best means of conserving vital materials for war purposes. Covered Neutral Cable conserves the most materials, saves man-hours because it is readily installed, and facilitates correct circuit polarization because it is virtually impossible to confuse the grounded circuit conductor with a covered wire.

Although many of the new developments in wiring methods and materials, and the Interim Amendments providing for their use, are strictly war time expediencies, some of them may remain after the war because they represent sound engineering practices and real progress in the electrical field. Meanwhile, every available man-hour and every ounce of material must be made to produce the maximum results. Let's fight this war with everything we have.

EEI PUBLICATIONS

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Meter Specifications

Institute Publications Sponsored by the Meter and Service Committee, EEI, and the Committee on Metering and Service Methods, AEIC

A NEW series of specifications issued under the sponsorship of the Meter and Service Committee, EEI, and the Committee on Metering and Service Methods, AEIC, began with the publication in 1940 of MS-1, "Suggestions for Specifications for Standard Dial Constants for Alternating Current Watthour Meters" and MS-2, "Suggestions for Specifications for Coordinated and Standardized Low Voltage Metering Current Transformers."

The intent in compiling and issuing such specifications is that they be used by the utility companies as an aid in preparing their own specifications for purchase and use and in this manner be useful in promoting uniformity in metering practices and the manufacture of metering equipment. It will be appreciated, therefore, that familiarity with these publications on the part of operating utility companies is of considerable importance to the industry.

Recently in 1942, two additional specifications have been published. These, in addition to having the approval of the Meter and Service Committee of EEI, also are approved by the Committee on Metering and Service Methods of AEIC and represent the present conclusions of a comparatively large group of metermen which have been concurred in by the Meter and Instrument Transformer manufacturers. It is expected that their observation by a major portion of the operating utility companies in the country will result in material benefits not readily available by other means. These later two publications are as follows:

MS-3, "Specifications for Standard Current Transformers for Primary Circuits."

The specifications cover a standardized line of general purpose current transformers of the indoor type in three voltage classes. Insulation levels, salient dimensions and current ratings for metering purposes have been specified. Insulation levels comprise the 5, 8.66 and 15-L classes of ASA Standard C-57 Section 4.051 for current transformers. Dimensions are such that all transformers of a given class are interchangeable. Only seven current ratings for metering purposes have been chosen to cover the range to 800 amperes rating. It is expected that transformers made to these specifications will ultimately substitute for all other general purpose indoor current transformers now available in these same three voltage classes.

MS-4, "Specifications for Indicating and Cumulative Demand Register Scales."

These specifications cover a standardized line of demand registers for watthour demand meters of the block interval types which will permit a material simplification of requirements for such devices if substantially observed. Scale capacities in the standardized line cover uniformly required ranges of measurement from 0.5 to 480 kw full scale in the standard voltage and current ratings.

The line has been based fundamentally on a system of register constants conforming to Publication MS-1 but it will be found that registers are available to conform to most of the so-called "Universal" register systems in use. Certain direct reading demand dials and all 5 dial registers are omitted from the standard and are considered as "special" by the standard but will be available as such.

All metermen will appreciate the fact that these specifications greatly reduce the multiplicity of register types, ratios and scales now required for a given line of watthour meters and offer the opportunity for consolidating and unifying all the various practices with respect to indicating demand measurement now in vogue throughout the country. This also involves accounting procedure and meter reading.

As the full import of these specifications is more thoroughly appreciated and the tremendous advantages of better standardization through modernized practices becomes more apparent, it is quite possible that a further simplification in demand register requirements can be made but this cannot be accomplished until the individual practices of operating companies in this respect become more uniform.

Copies of all specifications in the MS series are 10 cents each, and may be obtained from the Edison Electric Institute, 420 Lexington Ave., New York, N. Y.

Safeguarding Records from Air Raids

THE full report on "Safeguarding Records from Air Raids" discussed at the May 12 meeting of utility accountants in Cleveland by E. H. Conarroe, Director of Management Service, Policyholders Service Bureau of the Metropolitan Life Insurance Company, New York City, has now been completed and is available for distribution to public utilities.

The report is based on a survey conducted by the Policyholders Service Bureau to provide information on the manner in which this problem can be and is being met. Information was secured from about 50 companies, including industrial, financial, utility and mercantile organizations. These companies are located in various parts of the United States and Canada, although the majority are operating along the Eastern and Western seaboards.

The report notes that "The threat of air raids has created the problem of safeguarding important business records from a new type of hazard. Every business concern has records that would be difficult, and often impossible, to replace in the event of their destruction. . . . Company records have always been subject to such hazards as fire and flood, but war conditions have introduced the new hazards of demolition and incendiary bombs. Safeguards that may have been considered adequate under normal conditions may prove definitely inadequate to meet this new situation."

Although the survey indicated that business executives are aware of the problem, the actual development of the program has not progressed much beyond the investigation and planning stage. Well over half of the companies contacted reported this to be the case.

Financial institutions, notably banks, seem to have made the greatest progress in adopting a program. Several banks reported that they have set up a special organization for the purpose of air-raid protection, and have prepared their formal procedure in manual form.

As would be expected, geographical location plays an important part in the extent to which individual companies have been concerned with this problem. Inland companies consider themselves less vulnerable to air attack, and seem inclined to weigh more carefully the cost of a record-protection program against the probability of loss. Many companies, however, even though their headquarters are located well inland, operate branch plants or branch offices in more exposed locations for which protective steps need to be taken.

The development of a record-protection program involves three fundamental aspects:

1. Assignment of responsibility for the program.
2. Determination of material requiring safeguarding.
3. Method of safeguarding to be employed.

Each of these is discussed separately in the report.

Of particular interest to electric light and power companies is the following brief from the report on protective measures taken by a public utility company.

"This company approached the problem on the premise that no consideration could reasonably be given to safeguarding records from direct bomb hits; that the damage from fire resulting from bombs offered the most serious threat; that the maintenance of records at two different locations through the use of copies appeared to furnish reasonable protection, and that photographing of certain records was desirable.

"Immediate consideration was given to protection of the general corporate records, accounts receivable records, and the continuing property records.

"The loss of accounts receivable records would undoubtedly result in inability to collect the major portion of the accounts. Since these accounts were maintained on register sheets and duplicates could be readily prepared, this step was taken. Eventually duplicates were on hand for all receivables at various dates and these copies were distributed to various locations having vault accommodations, the originals remaining at the central office. Each month, as new register sheets are prepared, the new copies are substituted for the previous sheets, and the latter are destroyed. These records would have to be supplemented with additional data if it became necessary to put them to practical use. Consequently, a record of consumers was duplicated and filed in various locations, and cash coupons, after serving their purpose in the central office, were likewise filed. From these data, accounts receivable at any current date can be built up, and meter index books replaced with all necessary current information required.

"The continuing property record of a utility represents a large investment, the loss of which would be keenly felt. It was found to be practical to photograph certain underlying records and the card record carrying the property units. Although it was not practical to duplicate current work to the extent necessary to restore the record completely if lost, the filing of current data in other locations, once it has been recorded, reduces the period for which records might not be available to a minimum.

"General accounting records were readily duplicated in their main essentials, although, of necessity, considerable underlying data were ignored. Copies of trial balances, voucher registers, journal entries, and cash receipts and disbursement records are made currently and filed daily in locations removed from the central office.

"General corporate records, such as contracts, maps, and minute books, much of which is duplicated but maintained through necessity at the same location as the originals, are housed in vaults of such construction that only a direct hit could be serious.

"Employees' personnel records were all photographed. These records, which contain the complete history of an employee's progress throughout his employment as well as personal statistics, are vital.

"Maps of the distribution system, which are very essential records, were available in duplicate and were filed at different locations, so that no problem was experienced in this connection. Main intersection maps, however, were photographed.

"In some cases the photographing or obtaining and maintaining copies of records was not feasible. If such records were not exposed unduly to fire hazards in the event of an emergency, only the usual precautions against fire from incendiary bombs were taken. If, on the other hand, an emergency would create a definite fire hazard, it sometimes was found desirable to move personnel and records to a location considered less exposed."

Copies of "Safeguarding Records from Air Raids" are available on request to E. H. Conarroe, Director, Management Service, Policyholders Service Bureau, Metropolitan Life Insurance Company, New York, N. Y.

Salvaging Waste Light for Victory

By Arthur A. Brainerd and Robert A. Massey

Philadelphia Electric Co., Philadelphia, Pa., and E. I. du Pont de Nemours Co., Wilmington, Delaware, respectively.

Abstracted from a paper presented at the Wartime Lighting Conference of the Illuminating Engineering Society, St. Louis, Missouri, September 21-22, 1942

IN a previous paper* the authors have discussed and established as a fact, that the ability to see quickly, accurately and comfortably, may be greatly improved by creating a favorable color contrast in the immediate vicinity of the work. Since the presentation of this thesis, many industrial establishments have adopted the practice and their experience has substantiated the soundness of these conclusions. The purpose of this paper is to extend the area studied to include not only the working area, but the entire room, and also to devise a means for the intelligent selection of colors for any specific seeing job. Our data show that by means of a scientific use of color, it is practical to increase the illumination from most light systems 100 per cent without any change in lighting equipment or any increase in wattage.

The present commonly-used methods of calculating the performance of a lighting system were introduced previous to World War I, at a time when there were no instruments available for the rapid and accurate measurement of the illumination and brightness, and when relatively little was known of the illumination properties of paint. Illumination was measured in terms of lumens per square foot falling on an arbitrary plane, usually horizontal, and 30 inches above the floor. The area in square feet of this plane, multiplied by the illumination in footcandles, gives the number of useful lumens. This figure divided by the rated lumens of the lamp or lamps, is called the coefficient of utilization. By this method, if we had a room of 100 square feet in area, lighted by a 500-watt (10,000-lumen) lamp, the utilization coefficient would be 50 per cent if the illumination is 50 footcandles, or 100 per cent if the figure is 100 footcandles. Presumably, a lighting engineer who could produce 100 footcandles under these conditions would have achieved perfection and should look for other worlds to conquer. Strangely enough, 100 per cent utilization is not difficult of achievement.

The explanation of this phenomenon is quite simple. A lumen doesn't close its eyes, turn up its toes and die merely because it has fallen on a working plane. In fact, if given half a chance it will bound back and try again and again. Theoretically, a 10,000 lumen lamp could produce several hundred footcandles on the working plane in our 100 sq ft room. This phenomenon was commented on in an editorial in the *Electrical World*, Oct. 4, 1924. Professor H. H. Higbie in his "Lighting Calculations" shows a table of maximum theoretical utilization factors for various reflection-factors in an ideal room. For 98 per cent reflection, the utilization is 5000 per cent. From this it appears that our 100 per cent utilization is actually only 2 per cent of the ideal. Surely this is not too high a target to shoot at!

Admittedly, 100 per cent utilization requires careful planning, but the goal to be achieved is worth considerable effort. Let us take the case of a typical manufacturing area, as shown in Fig. 1, 40 x 100 ft, with a height of 12 ft. Assuming 70 per cent reflection for the ceiling and 30 per cent for the sidewalls, with direct type industrial lighting equipment we would expect a utilization of 40 per cent according to commonly accepted lighting tables. This includes an estimated depreciation of 30 per cent. Such a system would require 48 500-watt incandescent luminaries, or 114 two-lamp fluorescent units with 40-watt tubes, to produce 50 footcandles.

The calculations above are based on the assumption that no light is turned from any surface except ceiling and upper sidewalls. Roughly, this is about 40 per cent of the surfaces available.

Now let us consider the steps necessary to raise this illumination from 50 footcandles to 100 footcandles, with no increase in power consumption and with no change in equipment.

Let us start in then, by refinishing the ceiling with a high-grade white or light ivory paint, preferably having an eggshell or matte finish. It should be possible, with present finishes, to maintain an 80 per cent reflection-factor.

Next, refinish the sidewalls with a slightly darker paint such as light green, with a 65 per cent reflection.

Third, refinish all horizontal surfaces, benches, floors, tables, etc., in a paint of at least 40 per cent reflection-factor.

Fourth, give all machines a standard "3-dimensional" finish.

Now, assume that each luminaire emits 7000 lumens or 70 per cent of lamp-lumens. Of these 7000 lumens, 40 per cent or 2800 will be returned by the floors and benches. The rebound from the ceiling will be 80 per cent of 2800, or 2240, which is returned to the working plane. Note that in the complete cycle of reflection, we have recovered 8 x .4 or 32 per cent of the light striking the working plane. The complete sequence would be:

$$7000 + .32\,(7000) + .32 \times 32\,(7000) + .32 \times .32 \times .32\,(7000)$$
$$\text{or } 7000 + 2240 + 717 + 229 = 10186 +$$

This indicates a utilization of 101.86 per cent instead of 40 per cent. This calculation assumes that reflection from both floor and ceiling is perfectly diffuse and that all light from the luminaires goes directly to the floor. This condition is frequently achieved in large offices and manufacturing areas, and would be very closely approximated in the room under consideration. If the room should be relatively narrow, or the ceilings higher, the rebound from the sidewalls would, of course, be less than the direct light flux in the larger room.

In order to reduce the above calculations to a more general form:

Let Ee represent the efficiency of the luminaire
Rf—the reflection-factor of the floor
Rc—the reflection-factor of the ceiling
L—the lumen output of the lamp

It is then evident that in a very wide room the lumens usable on the working

* "Improved Vision in Machine Tool Operations by Color Contrast," Brainerd and Denning, *Illuminating Engineering*, Vol. XXXVI, No. 10, p. 1397

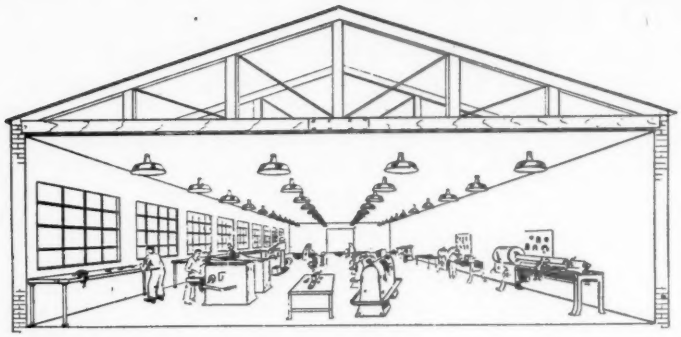


Fig. 1—Sketch of Suggested Industrial Area, Designed for Highest Light Utilization.

plane can be determined by the following formula:

$$\text{Usable flux} + L \times Ee + L \times Ee \times Rf \times Rc + L \times Ee \times Rf \times Rc \times Rf \times Rc + L \times Ec \times Rf \times Rc \times Rf \times Rc \times Rf \times N + L \times Ee$$

$$(1 + \overline{Rf\ Rc} + \overline{Rf\ Rc}^{2} + \overline{Rf\ Rc}^{3} \ldots\ldots\ldots \overline{Rf\ Rc}^{N})$$

For most practical purposes the series can be stopped at $\overline{Rf\ Rc}^{3}$. When the room is narrow enough that an appreciable light flux impinges on the walls, this result must be multiplied by a constant K_r depending on the room proportions and the reflection-factor of the walls.

Taking into consideration all of the above factors it is evident that if maintenance is taken seriously, it is quite possible by planned use of all available reflecting surfaces, to get at least 100 per cent more light for each watt consumed than is now the general experience. This result can be achieved with no change of equipment. Not only can it be achieved initially, but it can be maintained.

Description of Tests

The above statements are self-evident facts which come within the realm of our experience. The application of these principles necessitates considerably more detailed planning than we have been accustomed to. In order to demonstrate their practical application, a test room was selected whose dimensions are particularly unfavorable to a high light utilization. The room in question was 11 ft 4 in x 22 ft, with a 12-ft ceiling. The lighting was from two 16-in. enclosing globes each equipped with a 300-watt lamp, and giving a utilization coefficient of 22 per cent. In order to eliminate the fixture as variable, the original enclosing globes were replaced by two 500-watt silvered-bowl incandescent lamps on 18-in drop cords. In a room of these proportions, excessive brightness at the neck and upper part of the lamp was not a factor.[1] The room index for indirect lighting is given in the current tables as G. For indirect lighting the highest coefficient of utilization is given as 25 per cent.

The first step in the transformation was to install a suspended ceiling 10 ft high, and finish it with light cream paint giving a reflection-factor of 65 per cent. This change, and all successive steps are shown in Fig. 2. The surfaces of the room are described in Table I. Note that the light utilization is 27 per cent, which is very close to the calculated value of 25 per cent.

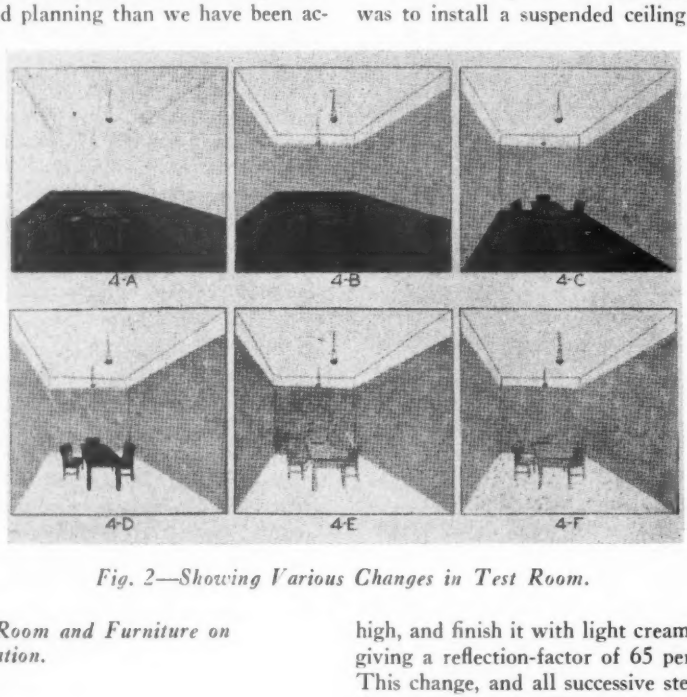


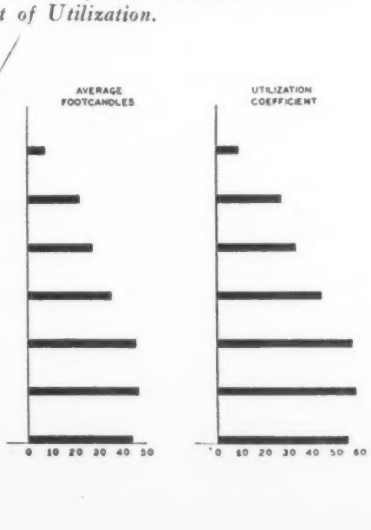
Fig. 2—Showing Various Changes in Test Room.

In the second step, the ceiling was repainted with a lighter color, bringing the reflection-factor up to 85 per cent. The resultant coefficient of utilization was 33 per cent, an increase of 22 per cent.

The third step consisted in finishing side walls with a neutral green paint slightly on the yellow side in hue, with

Table I—Showing Effect of Color of Room and Furniture on Coefficient of Utilization.

	CEILING	WALLS	FLOOR	FURNITURE
COLOR	12 FT WHITE	WHITE AND GRAY	DARK RED	DARK OAK
REFL. FACTOR	30	40	12	20
COLOR	10 FT. CREAM	WHITE AND GRAY	DARK RED	DARK OAK
REFL. FACTOR	85	40	12	20
COLOR	10 FT. CREAM	WHITE AND GRAY	DARK RED	DARK OAK
REFL. FACTOR	85	40	12	20
COLOR	10 FT CREAM	GREEN	DARK RED	DARK OAK
REFL. FACTOR	85	72	12	20
COLOR	10 FT. CREAM	GREEN	WHITE	DARK OAK
REFL. FACTOR	85	72	85	20
COLOR	10 FT CREAM	GREEN	WHITE	BLOND
REFL. FACTOR	85	72	85	30
COLOR	10 FT CREAM	GREEN	WHITE AND RUSSET	BLOND
REFL. FACTOR	85	72	70	30



[1] General Electric Tables.

reflection-factor of 72 per cent. The original finish had a reflection value of 40 per cent, and the gray dado a reflection-factor of 12 per cent. This change resulted in an improvement in room utilization of from 33 to 44 per cent. The men working in this room found the changed color scheme quite comfortable. There was no adverse comment.

The fourth step was to refinish the dark maroon floor which had a reflection-factor of 12 per cent, with white deck paint having a reflection-factor of 85 per cent. This resulted in a room utilization of 56.1 per cent.

The fifth step was to replace the dark mahogany table and chairs with blond furniture having a reflection-factor of 50 per cent. This step resulted in a light utilization of 58.5 per cent, an increase of 113 per cent over the original set up shown in block 4a of Fig. 2.

The sixth step was to stipple the white floor with russet, the approximate complementary color of the green used on the sidewalls. The resultant reflection-factor was 70 per cent, and the room utilization was reduced to 55 per cent. Note that the light utilization in this final case is exactly 100 per cent improvement over the original arrangement in Fig. 2.

Since the room was used as a classroom for several groups of mechanics, there was an adequate opportunity to get a frank opinion from men who did not hesitate to speak their minds. They watched the experiments with interest and were unanimous in their approval of the final arrangement. At their request the final experimental arrangement was made permanent.

The above simple set of experiments demonstrated three things:

1. Satisfactory hues may be secured without serious sacrifice in reflection properties.
2. Floor and table finishes of 65 per cent reflection-factor or even higher, are practical.
3. Coefficients of utilization of the order double the present practice can readily be secured by the use of high-reflection finishes of suitable hue.

In order to determine the everyday workability of these principles, several defense plants were contacted and arrangements made for large scale installations.

From a consideration of the investigations, it is apparent that only by the use of interior finishes having a very high reflection value (60 per cent or higher), can we expect to attain a maximum utilization of light. This applies to floors, furniture, machinery, and benches, as well as ceiling and side walls. From this it is apparent that adequate contrast for efficient and comfortable vision must be obtained through more of a contrast in "Hue" than in "Brightness." This applies to every surface which comes within our normal line of vision. From the standpoint of visibility, the working area and its immedate surroundings call for the most careful study. For brevity we have referred to colors for this purpose as "Spotlight colors."

From the very nature of the case, it is evident that there can be no "one" best answer to the color problem. After an extensive series of tests, *Spotlight Buff* was selected as the working color for machine tool operations on ferrous metals. Experience has shown that this color is not only satisfactory for the purpose for which it was designed, but for many other operations as well. However, there have been a sufficient number of demands for other hues to justify a more extended study of the whole spotlight painting problem. Briefly, our problem is one of selecting a spotlight color of high reflection value, having a satisfactory contrast in hue with the material being manufactured, and a color that will be continuously stimulating and comfortable to the workers.

Designing for Three-Dimensional Seeing

From the above discussion it is concluded that 3-dimensional seeing, properly executed, can accomplish three definite tasks:

1. Provide positive visibility with finishes having high reflection factors, by means of adequate contrast in hue.
2. Provide an overall contrast which is not too harsh to prevent continuous, comfortable seeing.
3. Provide a color sensation which is psychologically continuously pleasant and easy to live with.

In addition to the above localized results, the cumulative result of having all surfaces of high reflection value is to bring out a marked increase in light utilization.

As was shown, all surfaces within the room should have a high reflection-factor and therefore a definite hue contrast is desirable to compensate for low brightness contrast. And it is reasonable to suppose that as far as spotlight colors are concerned the best results would be obtained when working in the region of the greatest eye sensitivity. This would be near the center of the visible spectrum at about .5500 μ. It also follows that colors of low chroma (weak colors) are more comfortable on surfaces continuously in the line of vision.

Spotlight Buff fulfills these three conditions in a satisfactory manner. Its reflection value is high, 68 per cent. The bulk of the reflected light is approximately in the .5800 μ region and its chroma is quite low. Psychologically, it has a high degree of acceptance.

Spotlight Green, the second spotlight color, conforms even more closely to the theoretical specifications. It has a reflection value of 68 per cent, the same as Spotlight Buff. Its predominant hue is in the .5500 μ range. That is, it is a yellow-green. Its chroma is low, although not as low as Spotlight Buff. Psychologically, it is acceptable in a wide range of industrial operations, and it is especially popular in the textile industry.

While future developments may call for other spotlight colors, it is believed that the two already in use will meet the requirements of most manufacturing operations.

Horizon Gray is an achromatic or neutral color. As such, it will probably always occupy a prominent place as a background color. Its reflection value, 34 per cent, is high as compared with existing practice, although not as high as could be profitably utilized on horizontal surfaces.

The function of color as a part of the industrial seeing machine is to provide a controlled mild stimulation and to increase visibility by means of suitable contrast. Brilliant colors such as bright red or yellow, stimulate impulsive action and have their place as danger and caution indicators. Under such conditions, pronounced stimulation is deliberately produced in order to get instant action. Preventive action must be instantaneous if accidents are to be reduced. Achromatic colors (in other words, gray) have a deadening effect if used to the exclusion of chromatic colors, *i.e.*, those having hue and chroma characteristics. Somewhere in between strong chromatic color and achromatic color lies the position of continuous, comfortable, accurate vision with a minimum of fatigue. The need of the correct degree of stimulation within the working area cannot be disputed. It is equally essential, however, that the hue and brightness of the surroundings, including floor and ceilings, must be of such charcater as to emphasize a return of the eyes to the working area and to have their greatest comfort while there. In addition, these areas should have an adequate reflection value to insure the maximum use of multiple reflections. When all this is carefully worked out it is possible to work continuously and comfortably over floors

(*Continued on page* 355)

Mobile Demonstration Unit Aids Farmers In Maintenance of Electrical Equipment

By C. E. Jeerings
Rochester Gas and Electric Corporation

THE New York State College of Agriculture (Cornell Extension Service), working in cooperation with county agents and the electric utility companies, has for the last two years been carrying electrical knowledge to farm families by an unusually effective method. Using a large truck and trailer—the Wattmobile—representatives of the College have held demonstrations in almost every county in the state, and are now well along on their second tour of the farm areas.

The Wattmobile is equipped with all material necessary for a demonstration of how electricity works, what protective devices are for, and how an electric system and electric equipment should be cared for. In addition, it carries for display many essential farm electric appliances such as brooders, quick freezers, dairy water heaters, milkers, electric fence, etc.

Visits of the Wattmobile are planned by the county agent in cooperation with the local utility. Meetings are publicized by posters, news stories in the local papers, letters from the county agents, and, in some cases, by radio broadcasts. Power for the demonstrations is supplied by the local utility.

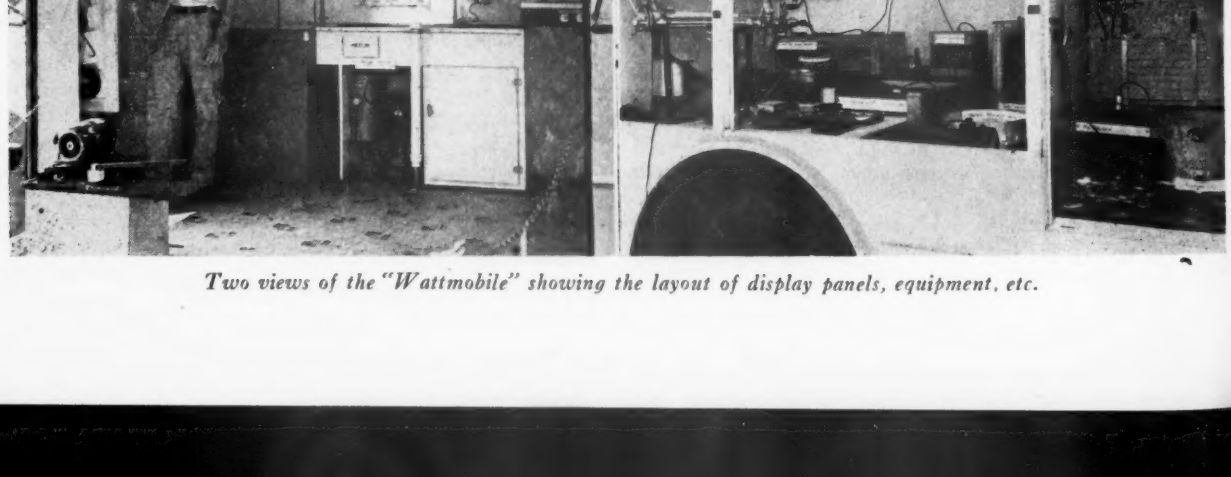
Because of the fundamental nature of the program, little modification has been necessary to make it an important element in the war production effort. The demonstrations were planned with three purposes in view: first, to help the farmer gain a better understanding of how electricity, wiring systems, fuses and protective devices work; second, to promote the more efficient use of electrical equipment; and third, to teach the care and repair of electrical equipment. With the increasing scarcity of critical materials more emphasis has been laid on home construction of many types of equipment.

The first step in a typical demonstration is to give the audience a clear idea of some essential facts about how electricity behaves. A panel is used on which is mounted two coils of tubing of equal length but of different diameters. Water is fed into both coils by a main feeder and a pressure gage registers the pressure at this point. The other end of each coil terminates in a large glass tube, and gages indicate the pressure at these points also. As water is allowed to flow through the tubing, the difference in pressure is made evident by the height of the jet thrown in the tube as well as by the pointer on the gage. The amount of water drawn in a given time is also used to make evident the relative efficiency of the two lines.

The audience is then told that electricity passing through the wiring system behaves very much like water passing through the tubing, and a second panel is brought out to show this. The arrangement of elements on this panel is similar to that of the former, but coils of wire, voltmeters and heating elements take the place of coils of tubing, pressure gages and glass containers. After the basic facts have been made clear, specific application to actual conditions is shown. Panels, each containing a number of outlets, are collected to the two demonstration circuits and duplicate appliances are plugged in on each side. These include toasters, coffee makers, brooders and lamps.

Bread is placed in each toaster, and the operator digresses for a moment to tell what happens to a motor under low voltage conditions. In the short period required for this talk, the heat in the toaster operating under proper voltage has been enough to burn the toast; in the other the bread has merely dried out. Streamers of paper attached to the brooder show that when voltage is too low, less air circulates, and hence the unit is not doing the job it was designed to do. By this time the coffee in one of the coffee makers is ready to drink, while the other is still cool enough to be held in the operator's hand. It is pointed out that these and similar conditions may exist on any farm, and instructions for

(*Continued on page* 353)



Two views of the "Wattmobile" showing the layout of display panels, equipment, etc.

McGraw Prize Paper

Procedure of Measuring Obsolescence in Machinery and Plants

By Kosmo J. Affanasiev

THE problem of obsolescence in public utility rate cases usually seems to revolve around the question whether or not there is obsolescence in property.

Most regulatory commissions assume that depreciation in public utility plants due to wear and tear, decay, corrosion, inadequacy, obsolescence and other causes takes place uniformly with time. In this, commissions rely on estimates of the average life expectancies of property usually arrived at by statistical processes where possible and on the basis of judgment where statistical information is too fragmentary.

Public utilities, on the other hand, maintain that the actual progress of depreciation is irregular and may be quite erratic. As to obsolescence, utilities state that there could be either little or no obsolescence in a modern plant while the plant is being economically used since, in such a plant, the factors of obsolescence are continuously anticipated.

It is difficult to say whether or not the above variance in view is due to the lack of a clear understanding of the processes by which machinery and equipment become obsolete. Doubtless, these processes are not widely understood. Yet, the term "obsolescence" as applied to public utility property is not new. One of the first references to it seems to have been made by the United States Supreme Court as early as 1913.[1] Another early reference seems to be that contained in the Interstate Commerce Commission's instruction to its engineers engaged in the valuation of railroads.[2] Since about 1920, the question of obsolescence was raised in a number of rate cases.[3] The problem of obsolescence has been discussed to some extent in literature, particularly during the past few years.[4]

It would seem therefore, that the subject of obsolescence as applied to public utility property is not so new as to either completely bewilder those who must be confronted with it or to justify assumptions that are often contrary to common sense. In view of this, a discussion of the meaning of obsolescence at any great length seems to be unnecessary, but there is a definite need for an attempt to answer the question: when and how obsolescence may affect the usefulness of machinery and equipment and how the effects of obsolescence may be measured? This is the primary purpose of this paper. In order, however, to make the discussion of the subject matter as clear as possible, it seems important to have at first some understanding of the underlying reasons why there has been a variance in the views as to obsolescence. Some of these reasons will be obvious from the present status of the depreciation problem as a whole as it is treated by the commissions and as it confronts the utilities. This will be briefly discussed first.

MR. AFFANASIEV

Mr. Affanasiev is the winner of the Third James H. McGraw Award for 1942.

He has been a member of the Engineering Department of the Pennsylvania Water and Power Company, Baltimore, since 1939 and has been engaged on engineering methods and applications of these methods for measuring plant depreciation, including inspections of plant at some intervals, studies of the justifiability of replacements of facilities and special studies in connection with regulatory matters.

Mr. Affanasiev was born and educated in Russia, having graduated from the Midshipman's College of the former Imperial Naval Academy and from Officer's Graduate School of Communications. Since his arrival in this country in 1930 he has supplemented his education as follows: graduate of Milwaukee School of Engineering, E.E. in 1930 and of the University of Wisconsin, B.Sc. E.E., 1932, M.Sc.E.E., 1935. He is a member of the A.I.E.E.

Depreciation Problem as Viewed by Commissions and by Utilities

The problem of depreciation that confronts the public utilities consists of two main phases. One of these is the problem arising from the necessity of making annual provisions for depreciation of putting aside annually a portion of the revenues so as to recover the cost of physical property at the time it is retired due to wear and tear, decay, inadequacy, obsolescence and other causes of depreciation. The second problem arises from the necessity of determining from time to time the depreciation existing in property for the purpose of arriving at the worth of property or the basis of rates.

The annual provision for depreciation may be made as a fixed proportion of the gross revenue, but most generally these provisions are determined on the basis of estimated average lives of physical property and some arbitrary method that may be recommended or even prescribed by regulatory authorities. Most commissions recommend but some of them require the use of the straight-line method, under which the annual provision is an amount obtained by dividing the cost of depreciable property, less its estimated

[1] Kansas City R.R. v U.S., 231 U.S. 423 (1913).
[2] ICC valuation Docket 2, Act of 1913, p. 127.
[3] For cases where there was some mention or a discussion of obsolescence as such or by inference, see Fundamental Legal Problems Underlying the Regulation of Interstate Telephone Rates—FCC Telephone Rate and Research Report, pp. 81-107, 6-15-1938.
[4] For published material on obsolescence, see Bibliography appended to this paper.

salvage, by its estimated life.[5] Some commissions permit the use of the sinking-fund method; others recommend and sometimes require the use of the compound-interest method.[6] Under the latter two methods the provision for depreciation is an annual amount such that the accumulation of these amounts over the estimated life of property, plus fixed interest on the accumulations compounded annually, equals the cost of the property less its salvage at the end of this estimated life.

Thus, the use of the above methods may be either voluntary on the part of the public utilities or through no choice of theirs. At any rate, a great many of the public utilities follow the straight-line method. A considerable number of them follow the sinking-fund method, a few follow the compound-interest method, and a few follow the fixed-percentage-of gross-revenue method.

With respect to the problem of determining the depreciation existing in property, most commissions contend that since the public utilities make or in any case should make provision for depreciation in property due to all causes including obsolescence, the accumulated sum of such provisions or the depreciation reserve, whether actual or theoretical, must be considered to represent the depreciation existing in property.[7] Quite often, commissions compute the so-called depreciation reserve requirement or a theoretical reserve by using a method and life estimates which may be considered by them to be more appropriate than the method and life estimates used by a utility. In general, if the depreciation reserve actually recorded happens to be much less than the theoretical reserve, commissions assume the latter to represent the depreciation in property. There has been one case, however, in which a straight-line theoretical reserve was assumed to represent depreciation in spite of the fact that the reserve actually recorded was greater than the theoretical reserve.[8]

[5] Under rules first promulgated by ICC and adopted later by FCC, the telephone utilities are required to use the straight-line method—FCC Unif. Sys. of Acc. eff. 1-1-1936, p. 23.

[6] A power company which had consistently used the sinking-fund method since the beginning of its operation was ordered by Fed. Power Comm. to adopt the compound-interest method—FPC Opinion No. 47 (1940) 34 P. U. R. (NS) 243 (1940).

[7] The depeciation reserve of a power company accumulated according to the sinking-fund method was assumed by Fed. Power Comm. to represent depreciation in property—See 34 P.U.R. (NS) 243 (1940).

The straight-line depreciation reserve of a power company was assumed by Fed. Power Comm. to represent depreciation in property—See 39 P.U.R. (NS) 275 (1941).

[8] F.P.C. Brief of Counsel Re Hope Natural Gas Co., pp. 85, 108-135, 9-2-1941.

Public utilities on the other hand maintain that the actual year to year progress in depreciation of physical property cannot be the same, unless by some accident, as the annual provisions for depreciation made on the basis of life estimates and some arbitrary method, such as: the straight-line method, sinking-fund method, etc. They point out that the life estimates are still only informed guesses and that even if such estimates were correct, the amount of depreciation reserve would vary, as it does, depending upon which one of the methods has been in use. Public utilities, therefore, determine the actual depreciation by inspecting the property, studying maintenance history and records, and by judgment based on their knowledge of the property.

Commissions criticize the inspection method contending that it ignores physical depreciation, such as: Wear and tear, decay and corrosion in items of property that cannot be readily inspected and that it generally ignores obsolescence. They maintain that obsolescence accrues, that is, accumulates gradually with time.

Public utilities in general take the position that with proper inspections and tests and comprehensive studies of property, all of the existing physical depreciation can be fairly determined. As to obsolescence, the view particularly prevalent among telephone companies seems to be that it is independent of the passage of time as such, that it occurs only as a result of definite and tangible new developments, and that it should be taken into consideration only when it occurs; that is, when it makes the existing equipment no longer desirable because of the economics of operation and other reasons; or when its occurrence in the near future is a certainty.

Irrespective of the relative merits and demerits of the above opposing views, an ultimate clarification of the problem of depreciation as a whole seems to require a proper understanding of the nature and the processes of obsolescence. With this in mind, a procedure of estimating depreciation due to obsolescence is offered in the next section of this paper.

Procedure of Determining Obsolescence

Meaning of Obsolescence

Obsolescence of machinery and equipment is said to be brought about by technological improvements. An improved machine might offer one or several advantages over an old machine, such as: a lower cost of operation and maintenance, a higher efficiency and a higher degree of reliability. Thus, it may be said that the extent to which the cost of production or of service can be lowered by replacing old units with improved units, or the extent to which the quality and reliability of service can be improved at substantially the same cost as or less cost than the cost of operating the old units, measures depreciation due to obsolescence in the existing units.

Basic Factors for Measuring Obsolescence

From this, depreciation due to obsolescence could apparently be determined on identically the same basis as the basis used in determining the justifiability of replacing any existing facilities for reasons other than wear and tear. In either case, it is not only the economic advantages that are important, but the relative reliabilities, efficiencies, flexibilities of operation, ease of maintenance and adaptability to future extensions and changes must be considered. In determining whether a given item of property should be replaced, its present value less salvage is included as a part of the cost of a substitute item. When the annual cost of operating a new item including the loss due to the retirement of the old item is equal to or less than the annual cost of continuing the old item in service, it is economically justified to replace the old item with the new available substitute. In some cases, replacement may be dictated by reasons other than the relative annual costs. At any rate, an item so replaced or found to be in need of replacement is fully depreciated from a point of view of its further function at its present location, although it might not be worn out. Its present value under this situation is no more than its salvage value, or its value in some other location, or as a stand-by plant.

Where the economic and other advantages of a new development are not sufficient to justify replacing an existing item with a new improved item, it would obviously be an economic waste to scrap the old item. Nevertheless, the results of such determinations serve to indicate the extent of the disadvantages at which the existing item may be operating as compared to a new substitute item.

Example 1

Let it be required to determine whether the cost of continuing a certain existing Unit A in service for some reason-

able period of time is greater or less than the cost of removing it from service at once and replacing it with a new substitute Unit B. Assume that Unit A is in good physical condition and, according to the best available indication, it could be continued in service for at least 15 years; it costs $8,000 to reproduce Unit A in its present condition; at the same time, a new substitute unit (Unit B), has been made available such that it can be installed for $8,000, it requires lower expense of operation and maintenance than Unit A and, according to the best available information, it is capable of being operated for at least 20 years. The annual operating expenses, consisting of the cost of operation, maintenance, taxes and insurance are estimated to be $1,900 for Unit A and $1,750 for Unit B.

Is is often customary in equipment selection studies to express the items of cost in terms of the present worth as of the date of study with a rate of interest corresponding to the average cost of money. Let 6 per cent be the rate in this example. Let salvage for Unit A at the end of 15 years and that for Unit B at the end of 20 years be zero. Then a comparison of the two units may be as shown below.

Before discussing the results of the above comparison, it should be noted that the total of items (3) and (4) or the present worth of depreciation and interest for the existing Unit A shown under Plan I is the same as the present value of that unit shown under Plan II. This relation is found to be always true in any comparison of this kind irrespective of the value assigned to the existing units. Since the difference between the totals under the two plans is not affected by adding the same amount to each total, the present value of the existing units may be omitted from the comparison. Thus, excluding $8,000 from both plans, the total under Plan I is $18,453 and that under Plan II is $23,770-S.

A comparison of the results under the above two plans shows that it is unjustifiable to replace Unit A with Unit B at present unless salvage S for Unit A on its replacement immediately is greater or equal to the difference between $23,770 and $18,453, or $5,317. In other words, if Unit A could be sold for $5,317, it would be justifiable to replace it with Unit B at once. Another way of looking at this result would be to say that it is just as economical to operate Unit A if purchased for $5,317, as it is to operate the new improved Unit B installed for $8,000. This seems to show that the present value of Unit A is $5,317 in comparison with the cost at which the new improved substitute Unit B can be installed; also, Unit A in comparison with Unit B seems to have a depreciation in the amount of $8,000—$5,317, or $2,683. But it should be kept in mind that this amount of depreciation arises from the following two facts considered in Example 1: (a) Unit A requires annually a greater amount than Unit B for operation, maintenance, etc.; (b) Unit A in its present physical condition is not capable of serving as long as Unit B.

			Present Worth	
	Amount	*Period*	*Factor*	*Amount*
Plan I — Continue Unit A in Service for 15 Years				
1. Value of Unit A	$ 8,000	..	....	$
2. Salvage at end of 15 yrs.	0	..	....	....
3. Depreciation at end of 15 yrs.	$ 8,000	15	.417265	3,338
4. Interest at 6%	480	15	9.712249	4,662
Total of Items (3) and (4)	....	..	....	$ 8,000
5. Operating Expense	1,900	15	9.712249	18,453
6. Total Present Worth of Cost of Operating Unit A				$26,453
Plan II — Replace Unit A with Unit B at Once				
7. Cost of Unit B	$ 8,000.00	..	....	....
8. Salvage at end of 20 years	0	..	....	....
9. Avg. Cost of Depr. on basis of 6% Annuity for 20 years	217.48	15	9.712249	2,112
10. Interest at 6%	480.00	15	9.712249	4,662
11. Operating Expense	1,750.00	15	9.712249	16,996
12. Value of Unit A.	8,000.00	0	1.000000	8,000
13. Salvage on immediate removal of Unit A	S	0	1.000000	S
14. Loss due to immediate removal of Unit A				8,000-S
15. Total Present Worth of Replacing Unit A with Unit B				$31,770-S

Depreciation arising due to fact (a) is by definition depreciation due to obsolescence, but depreciation arising due to the difference in the life expectancies of any new unit and old unit may be associated with physical depreciation rather than with obsolescence. It would seem, therefore, that for the purpose of estimating depreciation due to obsolescence, a comparison such as the above should in general disregard any difference in the life expectancies, unless such a difference has been created by developments in the art. (The difference in the life expectancies that is due only to the age of the existing equipment may be considered either directly or indirectly in the determination of wear and tear and other physical depreciation by regular inspections and tests.)

Example 2

A comparison of Units A and B disregarding the difference between their life expectancies would be essentially the same as in the preceding example, except that it would be on the basis of a maximum probable useful period for the existing unit *when new rather than in its present physical condition.* Thus, if instead of 15 years, the period of comparison were 20 years, the results of the comparison would be as shown in the table on the next page.

From comparison in Example 2, the following may be observed: (a) it is unjustifiable to replace Unit A with Unit B unless Unit A can be sold for the difference between the two totals shown in the example, or $6,279, less whatever wear and tear and other physical depreciation Unit A may have; (b) thus, the present value of Unit A as compared to the $8,000 cost of Unit B is $6,279 before deducting an allowance for physical depreciation; (c) it follows from this that Unit A is obsolescent in comparison with Unit B to the extent of the difference between the cost of Unit B ($8,000) and the above figure of $6,279, or $1,721; (d) if it were necessary to express depreciation due to obsolescence in Unit A with respect to its original cost, the amount of such depreciation would be the difference between the original cost of Unit A and its present value of $6,279 before deducting physical depreciation.

Mathematical Expression for Measuring Obsolescence

From the foregoing, the factors in-

	Amount	Period	Present Worth Factor	Present Worth Amount
Plan I—Present Worth of Total Cost of Operating Unit A for 20 Years				
1. Operating Expense	$1,900	20	11.469921	$21,793
2. Total				$21,793
Plan II—Present Worth of Total Cost of Replacing Unit A with Unit B and Operating Unit B for 20 Years				
3. Cost of Unit B	$8,000	..	....	....
4. Salvage	0	..	....	....
5. Depreciation	$8,000	20	.311805	$2,494
6. Interest	480	20	11.469921	5,506
7. Total, Items (5) and (6)				$8,000
8. Operating Expense	1,750	20	11.469921	20,072
9. Salvage on Unit A	S	0	1.000000	S
10. Total				$28,072-S

volved in the determination of the justifiability of equipment replacements may apparently be used for estimating depreciation due to obsolescence in the equipment. Example 2 may be used as the basis of a mathematical expression for measuring the present value of any existing property subject to obsolescence in terms of the cost of a new modern substitute property. The different quantities and factors used in Example 2 would in terms of arbitrary symbols be as follows:

e = Annual operating expenses for the existing units. These expenses consist of operation, maintenance, insurance, taxes, etc., but exclude depreciation and interest.

e′ = Same as e above but for the new improved substitute units.

C = Cost of the new substitute units.

n = Period of study in years. This should be a reasonable period corresponding to a maximum probable useful period for the existing units in their new condition, and not in their *present physical* condition.

S′ = Estimated salvage if any at the end of period n for the new substitute units.

(C−S′) = Depreciation of the new substitute units at the end of period n.

i = Rate of interest.

F_n = Factor $\frac{1-(1+i)-n}{i}$ for present worth of annuity corresponding to the end year of period n and interest rate i.

p_n = Present worth factor $\frac{1}{(1+i)^n}$ corresponding to the end year of period n and interest rate i.

V = Present value of the existing units in terms of the cost of the best available modern substitute units. This present value V is the same as S used in Example 2 and it is before deducting any allowance for physical depreciation.

Collecting the above terms and solving for V as in Example 2

$$V = (C-S')\,p_n + CiF_n + e'F_n - eF_n \quad (1)$$

The term $(C-S')\,p_n$ represents the present worth of total depreciation of the new units at end of period n. If the new units were to be n service beyond the period n, a general expression for depreciation would be $(C-S')\,a_NF_n$, where

a_N = Factor $\frac{i}{(1+i)^N-1}$ of S. F. annuity corresponding to interest i and to

N = Estimated reasonable life expectancy of the the new substitute units.

Thus, for a case where n is not the same as N,

$$V = (C-S')\,a_NF_n + CiF_n + (e'-e)F_n \quad (2)$$

But when N = n and since for N = n

$Ca_NF_n = Cp_n$, and $Cp_n + CiF_n = C$, then expression (2) becomes

$$V = C + (e'-e)\,F_n - S'p_n$$
$$= C - (e-e')\,F_n - S'pn \quad (3)$$

Neglecting salvage on the new substitute units, expressions (2) and (3) become respectively *

$$V = C\,(a_N + i)\,F_n - (e-e')\,F_n \quad (4)$$

$$V = C - (e-e')\,F_n \quad (5)$$

Expressions (4) and (5) are for the cases where the difference $e-e'$ is constant for each year of period n. If this difference were to vary from year to year, expressions (4) and (5) would be respectively

$$V = C\,(a_N + i)\,F_n - \sum_{o}^{n}(e-e')\,p_n \quad (6)$$

$$V = C - \sum_{o}^{n}(e-e')\,p_n \quad (7)$$

where p_n is $\frac{1}{(1+i)^n}$ corresponding to each year of period n, so that the term

$$\sum_{o}^{n}(e-e')\,p_n = (e_o-e'_o)\,p_o + (e_1-e'_1)\,p_1 + (e_2-e'_2)\,p_2 + \ldots + (e_n-e'_n)p_n \quad (8)$$

* For the purpose of determining obsolescence, scrap value or salvage should be omitted—For mathematical proof see Appendix.

In some cases, the difference in the efficiencies of the units compared may be of importance. Such difference, when expressed as an annual loss in production, could be incorporated in any of the above expressions. For instance, expressions (4) and (5) considering the efficiencies would become

$$V = C(a_N+i)F_n - (e-e')F_n - (E'-E)F_n \quad (9)$$

$$V = C - (e-e')\,Fn - (E'-E)\,F_n \quad (10)$$

Where E′—E is the annual loss in production due to the higher efficiency E′ of the best available new substitute unit or units than efficiency E of the existing unit or units compared.

On Proper Use of Formulas

The choice between any of the above expressions depends upon circumstances surrounding each particular equipment compared. As to choice between each pair of expressions such as (2) and (3), (4) and (5), etc., this choice depends on the period n used. In general, in selecting a period of study, the difference between the life expectancies of the equipment compared should be disregarded if such difference is due only to the fact that the existing equipment is physically not as good as new. In other words, if the existing equipment in its new condition had about the same life expectancy as the best available new substitute equipment, then the choice falls upon the second expression of each pair, or expression (3) of pair (2) and (3), expression (5) of pair (4) and (5), etc. If the best available modern substitute reasonably appears to have longer life expectancy than the existing equipment in its new condition, then the choice falls upon expression (2) of the (2) and (3), expression (4) of pair (4) and (5), expression (6) of pair (6) and (7) and expression (9) of pair (9) and (10).

Conclusions

1. Whether obsolescence "accrues" or "occurs", it seems to be clear from a brief analysis of the problem presented in this paper that the actual economic effects of obsolescence on any existing equipment do not begin to be felt until a new improved substitute is developed and made available such that it makes the operation of the existing equipment at a certain disadvantage. Such a disadvantage in the operation of the existing equipment, in comparison with any one best modern available substitute, does not in any way increase from year to year, but remains constant until some other improved equipment is developed such that it makes the first improvement no longer the best available modern substitute.

2. In other words, depreciation due to obsolescence occurs as a result of definite improvements and for any one improvement it remains constant irrespective of whether or not it is sufficient in magnitude to replace the existing equipment. Obviously, if it is sufficient to justify the replacement, the existing equipment is fully depreciated, except its value for other purposes as pointed out previously. Where economic and other advantages of a new development are not sufficient to justify the replacement, the fact remains that the existing equipment is not as economical to operate as a modern substitute. This latter condi-

tion apparently is a state of partial obsolescence. Unquestionably, by competitive standards, partial obsolescence makes the existing equipment less valuable than if a modern substitute had not been made available, because it is less profitable to operate the former than the modern substitute. Whether or not partial obsolescence in public utility property should be recognized apparently depends to what extent the standards of the strictly competitive industry are injected into public utility rate making.

3. If the advantages of Unit B over Unit A in example 2 are with respect to the annual cost of operation and maintenance only and if there is no definite improvement in Unit B as regards its life expectancy, then the amount of depreciation due to obsolescence in Unit A as compared to Unit B is $1,721. It will be noted that this amount is a function of the difference between the operating expenses of the two units compared and it is independent of what the existing unit might have cost.

4. The amount of depreciation due to obsolescence in the existing unit related to its original cost is the difference between this cost and its present value as determined in Example 2, and as it can be determined by any one of the mathematical expressions presented here. Thus, if the original cost of Unit A had been $7,000, depreciation due to obsolescence as related to this cost would be the difference between $7,000 and $6,279, or $721.

5. The method of measuring obsolescence presented in this paper is essentially an engineering method of equipment selections or a method of determining the justifiability of replacements of equipment. Both are based on the relative economies of operation and relative operating characteristics of the equipment compared. As such, the method can be used to show the year to year advantages and disadvantages of continuing any existing equipment in service for any period during which it might normally be operated. In this respect, the method seems to be more flexible and more comprehensive than several other methods that have been proposed during the past few years.[9] In addition, the method presented here can be used so as to take into consideration any increase in the life expectancy of a modern substitute that may be brought about by developments in the art.

[9] For other methods, see Bibliography.

Alfred H. Schoellkopf

ALFRED H. SCHOELLKOPF, president of the Niagara Hudson Power Corporation and a member of the Board of Trustees of the Edison Electric Institute, died Sept. 9 in New York, after an illness of several months.

Mr. Schoellkopf was 49 at the time of his death and had been associated with the Niagara Hudson and its predecessor companies for 27 years. Despite his comparative youthfulness, he had been long recognized as one of the outstanding utility leaders in the country.

He was the son of C. P. Hugo Schoellkopf and the grandson of Jacob F. Schoellkopf, pioneer of hydro electric power development at Niagara Falls. He died within an hour of the death of his uncle, also named Jacob F. Schoellkopf. The latter was president of the investment firm of Schoellkopf, Hutton & Pomeroy and he, too, had been prominently identified with the hydro electric development in the Niagara region.

Mr. Schoellkopf had been president of Niagara Hudson Power Corporation since 1933, and previously had been president of Buffalo, Niagara and Eastern Power Corp. since 1929. He was first employed by the Niagara Falls Hydraulic Power and Manufacturing Company in 1915 and became vice-president and director of the Niagara Falls Power Company in 1920. When Buffalo, Niagara and Eastern Power Corp. was formed in 1925 he became a director and vice-president of that organization, serving as its general manager until 1929. Mr. Schoellkopf was also chairman of the board of New York Power and Light Corp. and a director of several other Niagara Hudson System companies.

An extremely capable executive, Mr. Schoellkopf was able to devote considerable time to extensive philanthropic and cultural activities as well as to non-profit cooperative enterprises of the electrical industry, the latter including service as president of the Electric Utilities Exhibit Corporation during the New York World's Fair in 1939 and 1940, and leadership in the affairs of the Edison Electric Institute for many years.

Mr. Schoellkopf was chairman both of the New York State Board of Social Welfare and of the Welfare Council of New York. During the worst years of the depression he was chairman of the New York State Temporary Emergency Relief Administration, succeeding Harry Hopkins in that post when Mr. Hopkins became Federal Emergency Relief Administrator.

Funeral services were held at the Church of the Heavenly Rest in New York and burial was in Buffalo. Surviving are his widow, Mrs. Virginia Partridge Schoellkopf, and two daughters, the Misses Ann and Joan Schoellkopf.

APPENDIX

Proof Why in the Measurement of Obsolescence Scrap Value or Salvage at the End of Estimated Life N, or at the End of Period of Study n Should be Omitted.

A general expression for the present value new of the existing units in comparison with a modern available substitute was given by expression (2), or

$$V = (C-S')a_N F_n + CiF_n - (e-e')F_n \quad (2)$$

If the existing unit had been just installed, its value new in comparison with an identical new substitute has to be

V = C, because under this condition

N = n and e = e′, so that expression (2) becomes

$$V = Ca_nF_n + CiF_n - S'a_nF_n \quad (A)$$

But $a_nF_n = p_n = \dfrac{1}{(1+i)_n}$, or

$$\frac{i}{(1+i)^n - 1} \cdot \frac{1-(1+i)^{-n}}{i} = \frac{1}{(1+i)^n} \quad (B)$$

Also,

$$p_n + iF_n = 1, \text{ or}$$

$$\frac{1}{(1+i)^n} + i\left(\frac{1-(1+i)^{-n}}{i}\right) = 1 \quad (C)$$

From (A), (B) and (C)

$$V = C - S'p_n$$

But for the existing unit just installed, where e = e′ and N = n its value now should be identical to the cost of the identical substitute unit (assuming there has been no change in price level since the installation of the existing unit), or

V should be equal to C and not to $C-S'p_n$.

Therefore, in determining the value of the existing equipment for the purpose of estimating depreciation due to obsolescence, all considerations of scrap value should be omitted.

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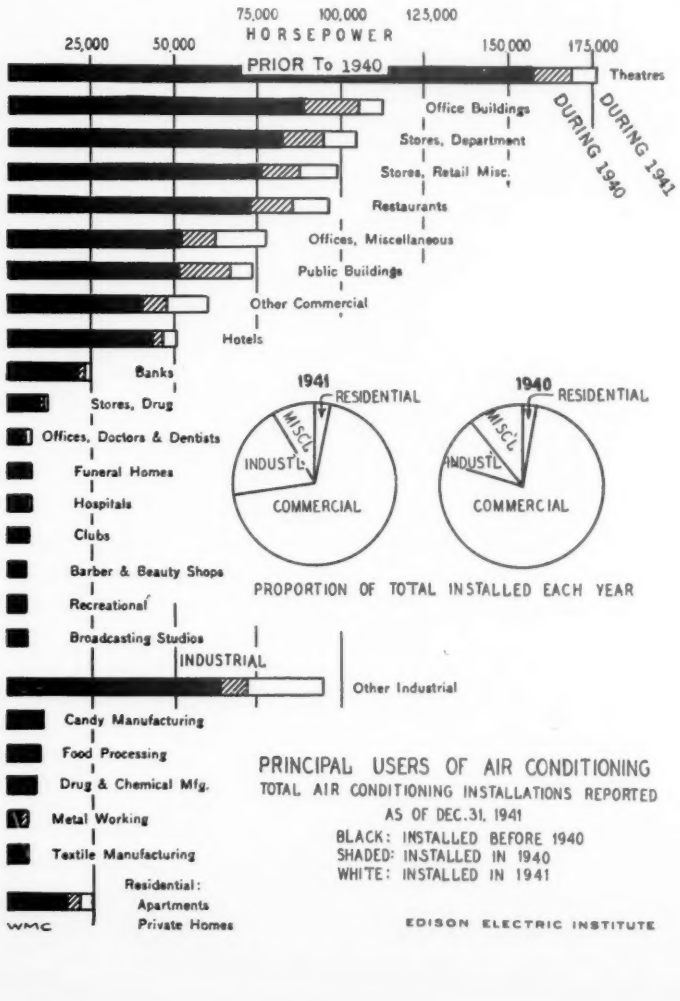
Growth of Air Conditioning in Recent Years

THE following figures have been computed from the various annual reports on air conditioning published by the EEI. The increased popularity of air conditioning in smaller establishments is evident. Where, in 1938, the size of the average installation was 14 horsepower, in 1941, this had decreased to less than eight and the average of *all* installations at the end of 1941 was exactly half the figure of four years earlier. Much of this has been due to the early acquisition of the large theatre and motion picture house load which, in 1937, comprised nearly 25 per cent of the total and averaged 100 hp per installation. During the next four years, the theatre load increased by only 35,000 hp although 800 more installations had been made, and by the end of 1941 it comprised only 15 per cent of the total and the average installation had declined to 80 hp.

During the past year, the greatest emphasis has been on industrial installations. In 1940 this class comprised 6 per cent of the number installed during the year and 9 per cent of the horsepower, while in 1941 the corresponding figure was 7½ per cent of the number and 20 per cent of the horsepower. These trends are illustrated by the accompanying chart.

AIR CONDITIONING INSTALLATIONS

Year	Installed During Year — Number	H.P.	Avg. Size	Totals as of December 31 — Number	H.P.	Avg. Size
As Reported by 150 Companies at the Close of 1941						
1941	18,518	142,854	7.7 hp	81,978	1,196,067	14.6 hp
1940	15,844	148,484	9.4	63,460	1,053,213	16.6
1939				47,616	904,729	19.0
As Reported by 177 Companies at the Close of 1940						
1940	15,778	148,341	9.4	63,468	1,083,121	17.1
1939	12,534	134,805	10.8	47,690	934,780	19.6
1938				35,156	799,975	22.8
As Reported by 184 Companies at the Close of 1939						
1939	11,998	125,179	10.4	44,055	910,142	20.7
1938	10,000	139,000	13.9	32,057	784,963	24.5
1937				22,057	645,963	29.3



New EEI Publication

CABLE OPERATION—1940

EEI. Pub. J-3. A joint report of Committee on Power Distribution, Association of Edison Illuminating Companies and Transmission and Distribution Committee, Edison Electric Institute, 21 pages. Price 50c to members and their employees; $1.25 to nonmembers in the U.S.A.; $1.35 to foreign countries.

THIS report combines the essential features of the annual cable operation reports which in previous years have been prepared separately by the AEIC and EEI committees. In connection with this change in procedure there has been a reduction in the number of contributors which, however, has reduced the amount of equipment reported by only about 10 per cent.

There has been very little change in the cable trouble rate. The total cable trouble rate of 6.9 is the same as the corresponding rate for 1939 for the same contributors, though slightly higher than that of 6.5 for all contributors for the 1939 report. There was a small decrease in the failure rate to 4.7 from that of 4.9 for the corresponding contributors to the 1939 report, which was offset in the total trouble rate by an increase in the removal rate.

There has been practically no change in the joint trouble rates from those of 1939.

The total trouble rate for potheads was 3.1, the failure rate being 1.5 and the removal rate 1.6. These rates continue the steady decrease in the total rates of the past four years.

The study of the causes of cable troubles has been expanded to cover all troubles reported. Data have also been added on the causes of trouble in joints.

An Effective Farm Service Program Based on Study of Individual Needs

Rural Service Activities that won Martin Award for Puget Sound Company

A PROGRAM of services based on a close study of the varied farm needs in their own territory won the 1942 Thomas W. Martin Rural Electrification Award for Puget Sound Power and Light Company. The award was presented at the annual meeting of the Institute held in New York in June.

In the Puget Sound program sales campaigns, as they are usually understood, played no part. Instead, the farm electrification field men, through close personal contact with individual farmers, analyzed individual problems and brought them to the company's Farm Electrification Laboratory for solution.

At times, the problem was one which could be solved by the application of more or less standardized agricultural practices; at other times considerable research and experimentation were necessary. In some cases, the experimental work is still going on, for the company has been careful to distinguish between tentative results and demonstrated facts.

Typical Service Tasks

In the presentation submitted in competition for the Award, J. C. Scott, the company's Farm Electrification Director, lists fifteen typical rural service tasks which have been undertaken in the last year:

1. *Irrigation*—More than double production on 2975 acres of farm lands, already in production, by the installation of 119 electric irrigation pumps during 1941. Irrigation in the humid region of Puget Sound is due entirely to the educational and promotional work of this company over a period of many years. Pasture production is doubled and the green grass season extended for a period of three months, resulting in 20 per cent more milk production at 40 per cent less feed costs. Irrigation doubles fruit yields and also doubles and even triples commercial garden yields in this region.

2. *Poultryhouse Blackouts*—Due to war conditions, it was necessary for poultrymen to black out poultry houses at several intervals during the past winter when heavy egg production on commercial poultry farms depended upon lights. Not to light the chickens for even one evening may throw many flocks into a heavy moult, resulting in a serious decrease in egg production, which cannot be immediately corrected, and normally lasts as long as the chickens are moulting.

To black out the chicken houses by closing doors and windows resulted in as much damage as no lights, since the chickens require five to six times as much oxygen per pound body weight as other animals. So ventilation was necessary along with blacking out the lights. Puget Power's Agricultural Engineers, after careful tests, put out instructions to poultrymen as to how they may arrange their poultry house windows, doors, and ceiling ventilators to maintain air circulation and at the same time prevent any light from escaping to the outside.

Quick action on this problem actually saved poultrymen of Western Washington a loss of thousands of dollars by preventing their flocks from going off egg production during high prices.

3. *War Emergency Chick Brooder*—Another problem brought on by national defense activities was the difficulty in obtaining nichrome wire for the construction of chick brooders. Since our Federal Government is calling on poultrymen to increase poultry production, the obtaining of more brooders was imminent. Also, about 15 or 20 per cent of existing poultrymen who were using briquet coal for brooding were notified that they would not be able to obtain this material, and were further notified by the local War Production Board to use electric brooders. A survey of local brooder manufacturers and distributors disclosed the fact that electric brooders would be very difficult to obtain.

Substitute Materials Used

But a supply of tinned iron wire was found. Scientific tests were made in Puget Power's Farm Electrification Laboratory to determine the operating characteristics of iron wire used as a heating element in brooders, with the result that a new, economically constructed, radiant heat type brooder was designed, using iron wire as the heating element. This brooder was tested in the fall of 1941, and since many poultrymen brood the year around, and make plans early in the winter for the coming season, they were assured that electric brooders could be obtained when needed.

This activity was not only an assistance to poultrymen in this heavy egg producing area, but indications are that it will be a factor in increasing poultry production for our national Victory Program.

4. *Poultry Trough Water Warmer*—Thousands of laying hens in Western Washington are kept in individual laying cages supplied with a narrow, small watering trough running in front. It has been found financially beneficial to the poultryman to keep this water warmed up to not less than 50 degrees. A method was devised by Puget Power's Agricultural Engineers of laying electric hotbed cable in the small trough, covering the cable with building wax. Protecting the cable with wax was found necessary as the hens, thinking the cable was something of a worm, picked it up in their beaks and continually threw it out of the trough.

More Eggs Per Hen

The average benefit to poultrymen in the Puget Sound territory from warming water for heavy-laying hens is an increased lay of 12 eggs per hen. Years ago we promoted poultry trough heaters which are in common use for hens on the floor, and obtained reliable information from poultrymen to the effect that gross profits from warming water in winter for layers amounted to at least $250 per year per thousand hens, but the above installation was our first successful attempt in warming water for the hens in batteries or individual laying cages.

5. *Tulip Bulb Drying*—Due to a disease attacking tulip bulbs in the territory west of the Cascades, the tulip bulb growers have decreased the produc-

tion to a point where this industry was nearly extinct. The disease is known as Botritus disease, which attacks the tulip bulbs when the inner layer of skin is broken, due to improper curing. Our Agricultural Engineers found that by holding proper temperatures during drying periods, and at the same time controlling an even flow of air throughout the entire room, also controlling humidity, that the inner skin of the tulip bulbs would not crack. Tests in growing of bulbs proved that such plants did not contract the Botritus disease.

This preliminary experimental work has been done in former years; however, during the past year we have been successful in improving the setup and installing an electric driven fan and thermostat controlled electric heater for large bulb storing warehouses, which have given entire satisfaction. This has saved hundreds of dollars for the growers and indications are that the tulip bulb industry will come back into its own in this territory.

Orchard Moth Control

6. *Control of Codling Moth in Apple Orchards in the Wenatchee Apple Growing Territory*—The use of lead arsenate solution as a spray in the apple orchards for the control of codling moth has brought on a serious problem of washing the apples to remove the spray residue. Furthermore, the chemical treatment by lead arsenate is not as effective as it formerly was, since each year the percentage of wormy apples seems to increase. Three years ago, experiments were set up in our company-owned orchard at Wenatchee for the purpose of testing out different colors, types, and kinds of lights, attempting to attract and trap codling moths in sufficient numbers to reduce the worms, and at the same time cut down spray requirements. During 1941 encouraging results were obtained and much attention was given to this problem, although the experiments have not progressed far enough to make definite recommendations at this time.

Sun Lamps for Poultry

7. *S-4 Sun Lamps vs. Codliver Oil for Poultry*—The climatic conditions around the Puget Sound territory are foggy and cloudy during the fall and winter, necessitating the feeding of extra large amounts of codliver oil to the laying hens in order to keep up a high and profitable egg production during that time of year. Now the present war conditions have made it difficult for poultrymen to obtain a good grade of codliver oil; furthermore, the price of this material has advanced recently. Our company purchased several S-4 Sun Lamps, loaned them to poultrymen for the purpose of making tests and comparisons with ultra-violet irradiated hens and codliver oil fed hens. Reports are now coming in that the irradiated hens, which were fed no codliver oil, have held up in production, in body weight, and in general appearance to the same extent as the heavy codliver oil fed hens.

Health Better; Cost Less

In some cases, poultrymen report even better results with the S-4 lights. One poultryman, Mr. George Dynes, tried two of these lights in 250-hen pens on his 15,000-hen poultry farm, with the result that he recently bought 18 additional lights because, as he says, "The hens under the S-4 lights (not fed codliver oil), are doing as well or better than the hens fed codliver oil. Furthermore, the lights have effected a net saving for me of $150 a month, because of my not having to purchase codliver oil for the chicken feed."

The seriousness of this situation and the value of this demonstration to poultrymen who are striving to help win the war by increased poultry production, will be realized even to a greater extent if war conditions another year make it impossible to obtain sufficient codliver oil to keep egg production up to normal.

While experiments have been conducted at our state institutions with regard to ultra-violet radiation vs. codliver oil, yet it required practical demonstrations and the loan of equipment to sell the idea to our local poultrymen, which has been accomplished during the past year.

8. *Protecting Seed Fields from Wild Ducks*—For years, 90 per cent of the cabbage seed used in the United States has been grown in Skagit County, Washington. Also, many other garden seeds are produced in this county in large quantities. Some of these seed crops are planted in July, harvested the following July, and during the winter the fields are covered with a luscious green feed, attractive to a certain type of ducks, the Widgeons, which are vegetarians. While these ducks do not bother the fields during some winters, yet under certain weather conditions, thousands upon thousands will cover the seed growing fields, mostly at night, and have on many instances completely ruined the crops for some of the farmers in one night.

Ducks Duck Light

In January, 1941, Mr. Joe McMillan, one farmer who has been experiencing considerable difficulty in this connection, had noted that a certain portion of his field, on the outside of a bend of a road, where automobile headlights covered the ground at intervals, had never been bothered by the ducks. Our Agricultural Engineers devised a revolving, headlight arrangement and placed it in the field, with the result of a net saving to this farmer of $150 per acre in a turnip field, and $300 per acre in a cabbage seed field. Many such devices have been installed by the seed growers during the winter of 1941-42. The ducks have never bothered the crops where a moving light beam is used.

Electric Fur Drying

9. *Drying Fox and Mink Pelts*—The production of fox and mink pelts is another agricultural industry of our territory, and during 1941 one of the fur producers presented the problem that more effective, thorough, and quick drying would result in improved pelts. Our Agricultural Engineers designed a forced air and thermostat controlled electric heat arrangement in the drying room which has proven completely satisfactory to the farmers. This new development will be promoted among other fur growers.

10. *Electric Lamp Chick Brooders*—Due to the unavailability of nichrome wire, several poultrymen were assisted in the economical construction of flat topped brooders using electric light globes as heating elements. These brooders have worked out satisfactorily in this emergency so far.

11. *Control of Corn Ear Worm by Electric Light Traps*—In the commercial gardening area near Seattle, corn ear worm has become increasingly difficult to control. Puget Sound's Agricultural Engineers set up a series of electric light traps around one field, with the result that it was demonstrated to the farmers that effective control of this pest could be obtained by proper light traps.

12. *Improved Turkey Brooding Setup*—Turkey production amounts to a sizeable industry in our territory, and difficulty is generally experienced in early brooding of the young poults. These poults, when set under the warm brooder, seem so well satisfied that it is diffi-

cult to get them started to eating and drinking the first few days. One of our turkey producers, who, incidentally, raises from 7000 to 10,000 turkeys each year, thought he was kidding us when he made the statement, "You fellows ought to fix up a turkey brooder so that when a man walks into the brooding house in the morning he can see all the turkeys and get to them easily, instead of having to go to each hover, lift it up, then claw out poults and teach them to eat and drink."

Air Conditioned Turkeys

This remark resulted in our setting up an air conditioning heater, operated on a thermostat, in the brooder room, blowing warmed air into the room, the air being baffled so that none of the turkeys were in a draft. This arrangement held the temperature at 60 deg.

For turkey brooders, the 250 watt G. E. R-40 drying light was used without hover. Two of these lamps were placed over each flock of 100 poults. A 12-inch high pen made of building paper was used to hold them together in a 6-foot diameter area the first few days.

For some unknown reason, these turkeys started eating and drinking without help when the mash hoppers and water founts were placed under the rays of these lamps. The lamps were hung about 2½ feet off the floor, and furnished plenty of heat in the air conditioned brooder room for poult comfort.

So this turkeyman is now able to walk into his brooder house and see all of the poults without raising hovers. He is relieved of the job of teaching them to eat and drink. But what is far more important, the experiments last spring indicated that the brooding mortality would be reduced by at least one-half.

These drying lights should not be recommended for chickens in a cold room where the temperature drops below freezing, according to our experiments.

All-Electric Greenhouses

13. *Electricity a Real Money Making Assistance for Commercial Greenhouse Operators*—While the development and experimental work in devising electric soil heating, soil sterilization, and air heating arrangements for greenhouses was accomplished several years ago, it was not until 1941 that the Beall Greenhouse Farm was completely electrified to an extent where 119,000 kwhr were consumed on this one farm for the production of more produce per square foot of soil, and a much higher quality commodity produced. As a matter of fact, in the territory served by our company, there are now 240 all-electric greenhouse establishments, most of the installations having been made in 1941, while hundreds of other greenhouses were partly electrified.

14. *Fluorescent Lighting on the Farm* —Our Agricultural Engineers are testing the value of fluorescent lighting in poultry houses and dairy farms, and while the indications are favorable, definite results cannot be reported at this time.

15. *Frost Prevention* — Blueberries are usually produced in low, flat, wet areas where air drainage is poor. This presents a frost problem. One of our commercial blueberry producers noted, by the use of thermometers, that there was several degrees variation in the air temperature of the blueberry field compared with that on top of the adjoining hill. Upon his request for assistance, our Agricultural Engineers devised an electric driven airplane propeller arrangement which was installed on the hill. The warmer air was directed down to the blueberry field. The blower was turned on whenever the temperature in the blueberry field became critical. The results were entirely satisfactory in preventing frost injury during the past spring season on this farm.

8000 Farm Calls

In addition to the more than 8000 individual farm calls which formed the backbone of the program, the company's rural electrification field men conducted 27 farm electrification demonstrations, attended by more than 2000 farmers; gave talks at 128 farm evening meetings; organized and conducted 15 farm tours; wrote or supplied data for 84 newspaper stories of successful applications of electricity to the solution of farm problems; produced 70 farm radio programs; prepared and published a booklet of 32 page pages plus cover on "Electric Gardening."

The company's program of service to electrified farms involves close cooperation with agencies. The State Director of Vocational Agriculture in the schools asked for the company's help in making up a farm electrification course. Many such courses have since been established in rural high schools in the territory. Plans and specifications for various devices developed by the Farm Electrification Laboratory are much in demand by vocational teachers. The radio broadcasts are also popular as reference material in these classes.

Because, as Director Scott writes, "the theme of the company's farm electrification activities has always been service to farmers in helping them produce more and higher quality commodities at less cost," war conditions will require little change in the basic program. The problems of the farmers will be those of war time, and their solution will be made more difficult by the limitations on materials. The relationship between the company and the farmer will remain the same—and should, on the basis of past results, contribute materially to the nation's "Food for Victory" efforts.

Mobile Demonstration Unit Aids Farmers

(*Continued from page* 344)

avoiding and remedying them are given.

Further demonstrations show what makes fuses blow out and what should be done about them, how to protect motors from overload, etc. Appliances are demonstrated, home construction of equipment is discussed, and proper care of equipment is explained. People are invited to bring in their own appliances and are shown how to repair them.

It is the experience of utilities in areas where Wattmobile demonstrations have been held that the effort is well worth while and that it does much to help people get better use from their electrical equipment. The limiting factor is that outdoor meetings like these can be held only during the summer. For this reason some thought is being given to possible ways of utilizing this equipment during the winter, when farmers have more time to spare for meetings. If a movie could be made which followed the general outlines of these demonstrations it could be used to excellent advantage both by utilities and by county agents.

As the Secretary of Agriculture has pointed out several times recently, American farmers are asked to produce more than ever before, although there are fewer farm workers to do the job. Crop reports show that this task is actually being accomplished, in part because farmers are doing more work through mechanical and electrical power. Our own farm business has increased far beyond our expectations, and our rural service force is needed now more than ever.

"Modern Kitchen Bureau Communique" Makes Its Initial Bow

DURING the seven years of its existence, The Modern Kitchen Bureau has offered many helps for utilities and their dealers, but it is believed that none have been more timely, nor of greater potential value, than the new "MKB COMMUNIQUE," which makes its initial appearance this month.

The Bureau, sponsored jointly by the Edison Electric Institute and the National Electrical Manufacturers Association, has scheduled this 16-page publication to come off the press at frequent intervals. If the first issue—September, 1942—can be taken as a criterion, this publication should prove to be a gold mine of helpful information for harassed utility advertising managers.

What Can Take the Place of "Sell"?

Now that the war has put the damper on the "sell' in electric appliance advertising, companies have been casting about for a phrase or idea that sums up the situation for electric kitchen appliances. The Modern Kitchen Bureau seems to have put its finger on a "natural" in the phrase, "LUCKY ME! I'M AN AMERICAN! — BUYING WAR BONDS TODAY FOR AN ALL-ELECTRIC KITCHEN TOMORROW!"

The first issue of the Communique shows how this stirring theme puts patriotism back of the logical urge to save now and buy later. The Bureau explains that words without end have cautioned consumers to guard against mechanical mishaps, and that a remarkably good job is already being done on the subjects of vitaminized diets, balanced menus and wartime meals.

The Bureau goes on to say:

"The need . . . is for an advertising theme that anticipates the future and provides for the present—a theme that appeals through logic to common sense—a theme that capitalizes on the unusual situation, rather than stressing the misfortunes of restricted buying—and finally, a theme that appeals to patriotism today, pocketbooks tomorrow."

Pictures That Put the Story Over

The first Communique describes advertisements available in three different sizes in mat form at nominal cost. Art work in this series of advertisements is by Marshall Frantz—top-flight illustrator, well known to readers of popular magazines. Mr. Frantz's first illustration of the series has captured the crisp sparkle of a young housewife of the U.S.A. She vibrates with enthusiasm, and points to herself in a way that says she really means she is proud to be an American. This series of utility advertisements is "ready made" but this does not affect the flexibility of their use.

Words as Well as Pictures

While two different versions of body copy for the first advertisement are suggested, the way is left open for any company which wants to hand-tailor its own copy to suit local conditions. The Bureau, however, proposes that the basic appeal be retained, no matter how handled. The Communique explains that while under normal conditions there are many sound reasons for varying the direction and changing the appeal of utility advertising according to territorial differences—*these are abnormal times.* The problem is common to all. Large operations and small alike are seeking to accomplish one clearly-defined purpose: to maintain the structure of acceptance that a progressive advertising policy has built, and subsequently to prime the post-war market.

First MKB advertisement employs this Marshall Frantz illustration. Others in the series of "Pictures of the Month" include the powerful, red-blooded, two-fisted, home-front fighting man; and a fine old lady who typifies the all-American mother.

Who knows but what the young lady in this first advertisement of the series, as she says, "I'M BUYING WAR BONDS TODAY FOR AN ALL-ELECTRIC KITCHEN TOMORROW!" may be starting a great national movement that will help both to win the war and the peace to follow?

But That Isn't All

This advertising theme is only the opening gun of the MKB Communique.

The first issue of this inviting 16-page paper, written in newsy style, contains articles by such authorities as "Les" Moffatt, Editor, *Electrical Merchandising*, and William E. MacKee, Merchandising Director, Ross Federal Service.

It tells how to make a window display kit with interchangeable sections that can be used to make various combinations. It also describes numerous successful window display ideas.

There is a"Live Wires" department which combs the field for sparkling, usable ideas ranging from contests to check-charts, and in between.

The "Booklet Prospector" names and even prices, where available, eminently usable booklets which may be had from various associations and manufacturers.

The Communique discusses the use of the "Lucky Me!" theme on outdoor boards, and has another section—"What Other Utilities Are Doing" — that should be of especial interest to the industry. It does just what its name implies—tells what the other fellow is doing. To promote contributions for this section, $2 each for usable suggestions from utilities themselves is offered.

The sum total of the MKB Communique is that it is full of self-starter ideas—the kind that make utility advertising men put fingers to their temples and then reach for their pencils—or for the button that summons their secretaries.

PERSONALS

N. B. HIGGINS has been elected president and a director of the Safe Harbor Water Power Corp., Baltimore, Md., to fill the vacancy caused by the death of Frederick A. Allner.

An engineer of long experience, Mr. Higgins has long been identified with the development of the lower Susquehanna River, where the company's plant is located in Lancaster County, Pa. He was chief engineer of the Safe Harbor Water Power Corp. and of the Pennsylvania Water and Power Company, positions he resigned upon acceptance of the presidency of the Safe Harbor Company.

BARTOW VAN NESS, JR., formerly assistant to chief engineer of the Safe Harbor Water Power Corp., has been promoted to the position of chief engineer, and J. B. HOMSHER has been named purchasing agent.

FRANK A. TRACY has been named president of Sierra Pacific Power Co., Reno, Nev., to succeed the late H. A. Lemmon. Mr. Tracy, who has been associated with the utility industry for 23 years, was manager of Sierra Pacific previous to the promotion.

Following graduation from the University of Maine in 1919, he took a position with Stone & Webster Company in the Boston statistical department. Later he spent two years with the Ponce Electric Company in Ponce, Puerto Rico, as assistant superintendent of distribution.

From Puerto Rico he went to Pawtucket, R. I., where he remained for twelve years, serving in various capacities. He was assistant to the president when he left to take a position with the Sierra Pacific Power Company in Reno.

G. W. SPAULDING, formerly assistant chief engineer of the Pennsylvania Water and Power Company, Baltimore, Md., has been promoted to the position of superintendent of power and DONALD GUNN, formerly assistant to chief engineer, has been made chief engineer.

ELMER L. LINDSETH has been elected a vice-president of the Cleveland Electrict Illuminating Company. Mr. Lindseth has been associated with the company continuously since his graduation from Yale University in 1926, except for one year when he was connected with the North American Company in New York. He has been a production engineer and assistant to the president of the Cleveland utility.

F. E. PLUMMER has been appointed local manager at Greenville for Mississippi Power and Light Company. Mr. Plummer has been associated with the company for 15 years and was until his recent promotion a member of the treasury department in the Jackson general offices.

Walter F. Allen, Director of Publicity, Public Service Companies of New Jersey, has announced the promotion of JOSEPH A. GALLAGHER to Publicity Manager. Mr. Gallagher has been with Public Service since 1924. Previously he was associated with the Plainfield Courier-News.

J. F. STALEY of Denmark, S. C., has been named manager of the Williston branch office of the South Carolina Power Company. He succeeds VERNOR MERCHANT who has been promoted to be superintendent of the Beaufort division of the company.

W. H. STUEVE, in charge of sales to the petroleum industry, Oklahoma Gas and Electric Company, has been asked to serve as power consultant for War Emergency Pipelines, Inc. of Little Rock, Ark. Mr. Stueve will remain with the project until the electric power matters have been concluded.

Announcement has been made of the appointment of H. E. BRAUNIG to the position of general operating superintendent of the Central Illinois Electric and Gas Company, Rockford, Ill., succeeding Harry L. Pearson. Mr. Braunig has been superintendent of the central division of the Gulf States Utilities Co., at Beaumont, Tex., since 1917.

A. C. VEROCK, formerly with the Consumers Power Company, Jackson, Mich., has become a substation design manager for the Ohio Edison Company, Akron, Ohio.

DONALD A. TATMAN, assistant purchasing agent for the Arkansas Power and Light Company since 1931, has been promoted to purchasing agent. Q. C. SHORES, who has been purchasing agent as well as executive assistant, will devote all of his time in the future to executive duties.

RICHARD MCKAY, formerly manager of the rate department of the Washington Water Power Company has been appointed assistant general manager of the company. He has been connected with the utility since 1921.

ANDY LOFT, formerly connected with the Bellingham office of the Puget Sound Power and Light Company has been transferred to Mount Vernon as manager. WALTER R. CHITTY, for the past four years manager in Snohomish, has been assigned to the managership in Edmonds and FRANK BALLARD, formerly dealer representative out of Everett, has been appointed manager in Snohomish to succeed Mr. Chitty.

MILTON I. ALLEN has been appointed manager (acting), sales service division of the Philadelphia Electric Co., to succeed Morison Blake, now on military leave.

Salvaging Waste Light

(*Continued from page* 343)

having a reflection-factor of over 80 per cent.

In order to make the above information available in a usable form to American industry, a color selector has been devised by means of which a suitable selection of colors for any industrial area can be made in a single setting.

Conclusions

The investigation here described should be considered as a record of progress rather than the ultimate solution. We believe that we have, however, established the following as facts:

1. That carefully selected hue contrast will effectively augment brightness contrast for comfortable, accurate, continuous vision.
2. That it is quite feasible to use much higher reflection-factors on floors and walls without discomfort, than has hitherto been considered possible.
3. That the use of color does not necessarily mean a great sacrifice in reflection-factor.
4. That the use of multiple reflections above makes possible a degree of light utilization far in excess of existing experience with a consequent reduction in the need of critical materials and an increased return from the electric power used.

What of Tomorrow?

(*Continued from page* 336)

Servicing

Fortunately, mechanical servicing of electric water heating equipment so far has been at a minimum. Any decision made today to simplify or standardize electric water heaters and water heating installations will help further to minimize the service problems of the future. Standardization will tend to improve quality and reduce repair costs.

Summary

All of the probable savings thus indicated in this survey of manufacturers, when totaled, should result in a sizable reduction in the price to the ultimate consumer, to the extent that it is not offset by uncontrollable costs, such as taxes.

The estimated reduction in unit costs is based upon manufacture of standard units only. It is too much to expect that there will not be special requirements placed on the manufacturers by some of their customers. It seems only fair, however, that the cost of such "specials" be placed on those requiring them in order that the majority will not be burdened with the out-of-proportion expense created in the production of other than standard units.

Utilities Can Help Themselves

If lower priced, better quality water heating equipment will help the electric utilities to better weather the approaching uncertainties, then, of course, they are going to be enthusiastic in their effort to cooperate in this program. Present types of heaters sold or recommended by individual utilities vary only in minor degrees, if at all, from the standards being proposed and for this reason it should not be difficult to alter local specifications and types of service rendered to the extent necessary to eliminate deviations from standards. Any change, of course, may entail some revision of policies, and if so, will cause some extra-curricular activities for a brief period. If over the years to come this means more net in the till, then the effort is worth while.

A little more uniformity in installation specifications, type of service rendered and rate practice, all with due respect to local conditions, will go far in lowering over-all water heating costs to customers. It is not presumed that all utilities over the country can render the same type of service at the same rate and require all installations to be made to the same specifications regardless of local codes. But it is believed that many little idiosyncrasies peculiar to a property only because of a slightly different approach might be discarded without detriment and even to advantage of the serving company.

From this discussion a program has been evolved which may be helpful to the "Executive-in-charge-of-planning-for-tomorrow." Briefly:

1. Analyze and prepare your post-war market during the war period.
   a. Train your sales force to sell the cheapness of water heating service.
   b. Do not let customers forget the advantages of electric water heating service; convince them that inability to get necessary equipment is a sacrifice on their part.
   c. Obtain the enthusiastic support of plumbers and electrical dealers in the promotion of electric water heating service.
2. Review your policies with respect to water heating service to provide broadest customer acceptance, giving consideration to appliance cost as well as electric service cost.
3. Join the parade of other utilities and the manufacturers in their efforts to standardize.

CONVENTIONS AND MEETINGS

OCTOBER

5-6	Prime Movers Committee, Statler Hotel, Detroit, Mich.
5-6	American Gas Association, La Salle Hotel, Chicago, Ill.
5-7	International Association of Electrical Inspectors, Western Section, Book-Cadillac Hotel, Detroit, Mich.
8-9	Meter and Service Committee, Detroit, Mich.
12-14	American Society of Mechanical Engineers, Hotel Sagamore, Rochester, N. Y.
12-14	International Association of Electrical Inspectors, Eastern Section, Taft Hotel, New Haven, Conn.
14-16	American Institute of Electrical Engineers, Pittsburgh, Pa.
19-20	Electrical Equipment Committee, EEI, Hotel Gibson, Cincinnati, Ohio
19-20	Transmission and Distribution Committee, EEI, Hotel Gibson, Cincinnati, Ohio
19-21	International Association of Electrical Inspectors, Southern Section, John Marshall Hotel, Richmond, Va.
22-23	Pacific Coast Electrical Association, Business Development and Administrative Services Section, Californian Hotel, Fresno, Cal.
27-29	National Safety Council Congress, Chicago, Ill.
26-30	National Electrical Manufacturers Association, Waldorf-Astoria Hotel, New York, N. Y.

NOVEMBER

10	National Association of Railroad and Utilities Commissioners, Baker Hotel, Dallas, Texas

Engineering Committee Meetings in October

FALL meetings of Engineering Committees of the Institute have been scheduled as follows:

Prime Movers Committee, Statler Hotel, Detroit, October 5-6.

Meter and Service Committee, Detroit, October 8-9.

Electrical Equipment Committee, Hotel Gibson, Cincinnati, October 19-20.

Transmission and Distribution Committee, Hotel Gibson, Cincinnati, October 19-20.

A joint meeting of the Electrical Equipment Committee and the Transmission and Distribution Committee will be held on the afternoon of Monday, October 19.

The Meter and Service Committee will meet jointly with the Committee on Metering and Service Methods of the A.E.I.C. The meeting on the first day, October 8, will be held in the Engineering Society of Detroit section of the Horace H. Rackham Educational Memorial. This is at 100 Farnsworth Avenue, a short distance from downtown Detroit. It is the intention to complete all business in one day, October 8, but reservation arrangements should include staying over for October 9. Any additional meetings on October 9 will be held at the Detroit-Leland Hotel.

Accounting Executive Meeting Oct. 5

F. B. FLAHIVE, Chairman of the EEI Accounting Executive Committee, has sent notice to members of his committee that plans are being made to hold an informal dinner meeting of the committee at the Palmer House in Chicago, at 6:30 P.M., Oct. 5, for the purpose of organizing accounting work for the ensuing year, together with a discussion of the problems faced by the industry because of the war.

The date and time of this meeting have been selected in the interest of economy, transportation, etc., because several members of the committee are to be in Chicago at that time in attendance at the annual convention of the AGA.

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1942-1943

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Meter and Service, H. A. HOWERY, Kansas City Power & Light Co., Kansas City, Mo.

Prime Movers, J. A. KEETH, Kansas City Power & Light Co., Kansas City, Mo.

Prize Awards, P. S. YOUNG, Public Service Electric & Gas Co., Newark, N. J.

Rate Research, F. A. NEWTON, The Commonwealth & Southern Corp., New York, N. Y.

General Commercial, EDWIN VENNARD, Middle West Service Co., Chicago, Ill.

Statistical, W. G. BOURNE, JR., The Commonwealth & Southern Corp., New York, N. Y.

Transmission and Distribution, E. V. SAYLES, The Commonwealth & Southern Corp., Jackson, Mich.

Codes and Standards (a Subcommittee of the Operating Committee) H. B. BRYANS, Philadelphia Electric Co., Philadelphia, Pa.

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